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THE CEREBRAL CIRCULATION

I. OBSERVATION AND MEASUREMENT OF PIAL VESSELS *

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The purpose of this paper is to describe a new technic for observing and measuring the changing diameters of the blood vessels of the pia-arachnoid, together with fluctuations in intracranial and intravascular pressures. Of the many ways devised in the past for studying the factors which operate to control the blood supply of the brain, two general procedures have been found most useful. First, the recording of pressures within the skull and within arteries and veins in divers situations and under varying experimental conditions, and second, the direct observation of blood vessels on the surface of the brain through an opening in the skull. Each method has its advantages and its limitations. Up to the present time, the method of measurement and comparison of pressures has yielded more important data than that of direct observation. The technic of the latter, however, has never been perfected, nor have its possibilities been fully explored. It is noticeable that the two methods have seldom been used simultaneously to correlate the data obtained by each. As a result, erroneous conclusions have been drawn because some of the many variables were unrecognized or were not measured, and important questions still remain in dispute.

REVIEW OF LITERATURE

Good sketches of the earlier work on intracranial pressure and cerebral circulation are given by Mosso [1] and by Leonard Hill.[2] One of the earliest observations concerning changes in intracranial pressure is that attributed to Pliny (60 A.D.), who said: "Tradition has it that the brain of Zoroaster at birth pulsated so strongly that a hand laid upon his head was repelled: an augury of future brain power." Haller [3] was one of the first to do careful experimental work in this field. He noted the

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* This is the first paper of a series on the same subject.

1. Mosso, A.: Ueber den Kreislauf des Blutes im menschlichen Gehirn, Leipzig, 1881.

2. Hill, L.: The Physiology and Pathology of the Cerebral Circulation London, J. & A. Churchill, 1896.

3. Haller, A.: Dissertation on the Sensible and Irritable Parts of Animals, Translation from the Latin, London, 1755, pp. 20 and 21.

motion of the brain ascending with expiration and descending with inspiration, and correctly attributed this to rises and falls in intrathoracic pressure transmitted upward through the jugular veins. Later he stated that the brain does not have motion unless the cranium is removed, but he does not say by what means he arrived at the latter conclusion. In 1811, Ravina,[4] a practicing physician in an Italian town, seems to have been the first investigator to make use of a window. He inserted a short cylinder of wood into a trephine hole in a dog's skull. The top of this cylinder was closed by a watch glass, cemented in place. Pulsations of the brain with respiration and with heart beat were noted, though, as Mosso remarks, the air space in the cylinder would itself make this movement possible.

Donders [5] devised an air-tight window with elimination of the air space by pouring in fluid as the window was pressed into place. With a 45 power magnification, he was able to make some interesting observations. No movement of the brain surface with respiration or pulse was seen. When the nose and mouth of the animal were obstructed for so short a time as ten seconds, dilatation of many small vessels became evident. In a later publication,[6] he made the significant observation: "On stimulation of these nerves (cervical sympathetics) we have shown constriction of the small arteries of the pia mater followed later by dilatation." Unfortunately, the arterial pressure was not measured.

Other workers, especially Kussmaul and Tenner,[7] Ackermann,[8] Schultz,[9] and Riegal and Jolly [10] have made successful use of skull windows and have contributed interesting data of a qualitative nature regarding vascular dilatation and constriction, but again without coincident measurements of the pressure. Cushing [11] used a window in some experiments in high intracranial pressure, and recorded arterial pressure at the same time. He found that when the arterial pressure rose to compensate for anemia of the vasomotor center (produced by raising the cerebrospinal fluid pressure to a great height), the pial vessels, which had been blanched, became filled once more. Lewin,[12] through a window, noted hyperemia of the brain surface during asphyxia from carbon monoxide, and Lee [13] has recently used a window and at the same time

4. Ravina, A. F.: Mem. Acad. d. sc. de Turin, 1811, p. 61.
5. Donders, F. C.: Nederland. Lancet **5**:521, 1850.
6. Donders, F. C.: Physiologie des Menschen, Leipzig, S. Hirtzel, 1859, p. 139.
7. Kussmaul, A., and Tenner, A.: Moleschott Untersuchungen, 1857, vol. 3, p. 1.
8. Ackermann, T.: Arch. f. path. Anat. u. Physiol. u. f. klin. Med. **15**:401, 1858.
9. Schultz, A.: St. Petersb. med. Ztschr. **11**:122, 1866.
10. Reigal, F., and Jolly, F.: Virchows Arch. f. path. Anat. **52**:218, 1871.
11. Cushing, H.: Am. J. M. Sc. **124**:375, 1902.
12. Lewin, L.: Kohlenoxydvergiftung, Berlin, Julius Springer, 1920, p. 324.
13. Lee, F. C.: Am. J. Physiol. **74**:317, 1925.

has measured cerebrospinal fluid pressure in studying the action of histamine, but he did not record arterial pressure or measure the vessels.

The first record of a window with a washout system, permitting the injection of fluids beneath the glass is that of Leiden [14] in 1866. Using a magnifying glass, he verified Donder's observations that the brain within a closed skull did not show any movement if all the air bubbles were excluded. It seems rather strange that Leiden's device, which was a distinct step in advance over previous methods, was not further developed or put to better use.

Observations through a trephine hole with no window have been made by a large number of investigators since the earliest times, but, as in the case of the observers just mentioned, no accurate measurements of the vessels were made. In spite of this, some valuable observations have been made, notably by Callenfels,[15] Nothnagel,[16] Schuller [17] and Vulpian,[18] who studied the effect of nerve stimulation on pial arteries. More recently, Hirschfelder [19] showed that pial vessels react toward a variety of drugs in the same manner as retinal vessels, and in 1925, Florey,[20] with improved illumination and higher magnification, studied the effects of mechanical, thermal, chemical and electrical stimuli. Jacobi and Magnus,[21] in 1923, and Leake, Loevenhart and Muehlberger [22] in 1927, made another advance by taking photographs; the former with a magnification of 13.5 times, the later without magnification but with measurements of blood vessels taken from the subsequently enlarged prints.

Some of the difficulties encountered by previous investigators have been technical ones, and, in order to overcome these special apparatus has been devised and a new technic developed.

METHOD

In general the method has been to examine, measure and photograph the blood vessels of the pia mater of anesthetized cats, and at the same time to measure and record intracranial and intravascular pressure. In order to measure accurately the diameter of the vessels, it was found essential to secure the following conditions: complete immobilization of the skull, restoration of approximately normal intracranial pressure by insertion of a tight window and replacement of all air

14. Leiden, E.: Virchows Arch. f. path. Anat. **37**:519, 1866.
15. Callenfels, Van der B.: Ztschr. f. rationelle Med. **7**:205, 1855.
16. Nothnagel, H.: Arch. f. path. Anat. **40**:203, 1867.
17. Schuller, M.: Berl. klin. Wchnschr. **11**:294, 1874.
18. Vulpian, A.: Physiologie et Pathologie, Paris, 1875, vol. 1, p. 108.
19. Hirschfelder, A. D.: J. Pharmacol. & Exper. Therap. **6**:597, 1915.
20. Florey, H.: Brain **48**:43, 1925.
21. Jacobi, W., and Magnus, G.: Arch. f. Psychiat. **74**:126, 1923.
22. Leake, C. D.; Loevenhart, A. S., and Muehlberger, C. W.: Dilatation of Cerebral Blood Vessels as Factor in Headache, J. A. M. A. **88**:1076 (April 2) 1927.

beneath the window with an isotonic fluid, use of a relatively high magnification (from 80 to 200 times) and a micrometer eye piece with ready adjustability of the microscope on a mechanical stage.

The window (figs. 1 and 2) consists of a circular cover glass 18 mm. in diameter, cemented by hot beeswax to the under surface of a specially constructed steel ring. This ring is perforated by two holes into each of which the base of a 17 gage needle is soldered. The tip of a syringe can easily be fitted into either of these to permit the addition or withdrawal of fluid from beneath the window when the latter is in place. The periphery of the ring is slightly beveled and threaded so that it can be screwed by a wrench into the trephine hole, making its own thread in the bone.

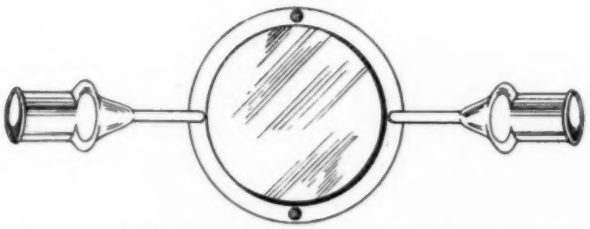

Fig. 1.—Top view of skull window showing circular cover glass and metal rim with bases of two hollow needles affixed, and two small holes in upper surface of rim for wrench used in screwing window into trephine opening. Reduced from a magnification of × 2.5.

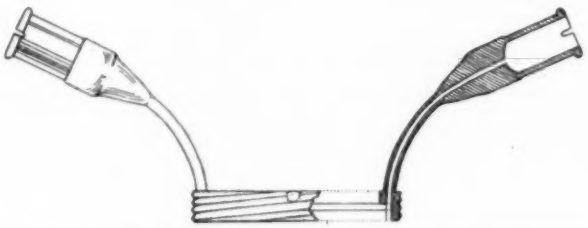

Fig. 2.—Side view of skull window showing metal rim, threaded and slightly bevelled, the two needles opening beneath the glass, and outlines of holes for wrench. Reduced from a magnification of × 2.5.

The anesthesia used is iso-amyl-ethyl-barbituric acid (amytal)[23] in 1 per cent solution (from 70 to 90 mg. per kilogram of body weight) injected into the peritoneal cavity. (In three instances, ether was the anesthetic employed.) The animal's head is fixed in a heavily constructed steel clamp (fig. 3) by several steel screws with swivel points pressing on the occipital bone and on the zygomatic arch. The clamp itself is firmly fastened to the operating table at such an angle that the animal lies flat on its side, the head nearly level with the body. A trephine hole is now made in the parietal region. As soon as the bone button is removed, an occipito-atlantoid puncture is performed, and from 1 to 2 cc. of cerebrospinal fluid is removed by syringe from the cisterna magna.

23. The author wishes to acknowledge the kindness of Eli Lilly & Co., Indianapolis, U. S. A., who furnished the material for experimental purposes.

The effect of this is to draw the surface of the brain away from the trephine hole. The dura is then lifted on the point of a needle and incised, a thin glass director is slipped into the incision, and a circle of dura is removed by a small pointed cautery, heated to a dull red. The object of this is to avoid oozing of blood from cut dural vessels. The pia and cortex are not injured by the heat of the cautery, for the dura is elevated by the director or by forceps. The next step is to screw the window into the trephine hole, to fill the space beneath the window with warm cerebrospinal fluid (or Ringer's solution) driving out all air bubbles, and then to cork tightly the holes in the rim of the window. Finally a 1 mm. bore glass manometer, filled with Ringer's solution up to a point 100 mm. above the cistern needle, is connected by a short rubber tube to the latter to serve as an intracranial pressure gage. A cannula in the femoral artery is also connected with a mercury manometer.

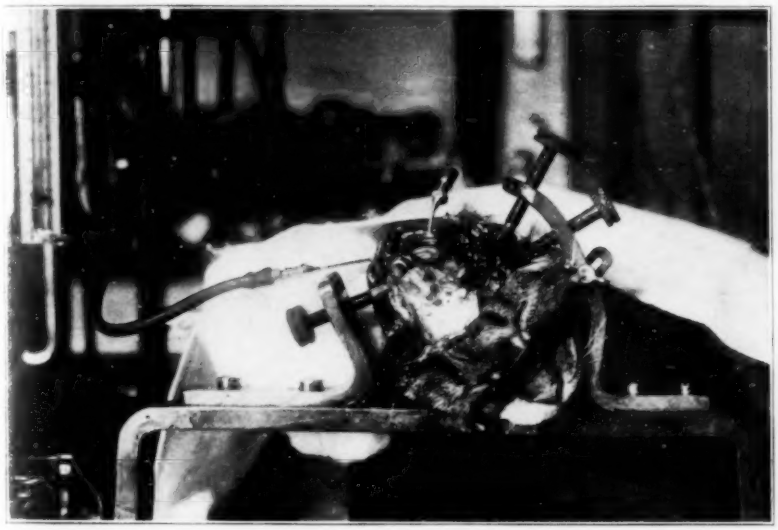

Fig. 3.—Photograph of clamp showing cat's head with skull window in place, cistern needle and manometer.

The microscope (its stage and substage equipment removed), permanently mounted on a large mechanical stage which can be clamped at will to the table, is now set in place so that its barrel is above and nearly perpendicular to the window (fig. 4). The source of illumination found most satisfactory for prolonged observation is a filament lamp of the "Point-O-Lite" type. Its beam is filtered through a green solution (10 per cent copper sulphate with a few drops of saturated aqueous solution of picric acid) in order to remove heat rays and to make the blood vessels stand out more distinctly against the background. The beam is then focused to a point on the window and the cortex beneath. An ocular micrometer scale, which can be rotated across any desired blood vessel, completes the equipment for observation.

For photography, a small Zeiss camera of the "Phoku" type is attached to the microscope in place of the ocular, and in order to permit a rapid succession of exposures, a special magazine has been constructed. With this, five plates can be exposed at intervals of five or ten seconds. Besides the usual black

and white photographs it has been found possible to take colored plates, both lumière autochromes (fig. 5) and Agfa, and these have been of real value in experiments during which changes from oxyhemoglobin to reduced hemoglobin, methemoglobin or carbon monoxide hemoglobin occur.

NORMAL APPEARANCES

Under the experimental conditions of anesthesia, posture, closed skull and others already outlined, the following observations have been made: No movement of the surface of the brain is visible, even under a magnification of 200 diameters, and photographs of two minutes' exposure show no blurring. But, although the brain surface does not show

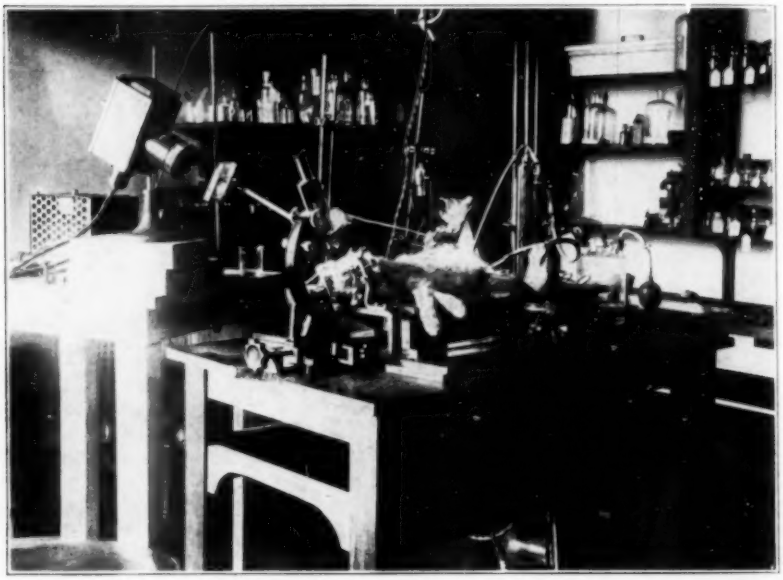

Fig. 4.—Photograph of apparatus ready for observation. On the table lies the anesthetized cat, its head fixed in the clamp. Above the head is the microscope mounted on a mechanical stage. On the left is the lamp and color filter; behind the microscope the cerebrospinal fluid manometer, and to the right that for femoral artery pressure.

general pulsation with respiration or with heart beat, the larger arteries, wherever there is a bend, throb with each cardiac systole; that is, they bend and straighten slightly, tugging along with them the cobweb-like arachnoid and the veins close by. This jerking of the arteries becomes less in the smaller peripheral arteries. None is visible in the smallest twigs. The color contrast between arteries and veins is striking, the arteries appear bright scarlet, the veins purplish red. Capillary loops have not been distinguished, but fine arterioles that admit red blood

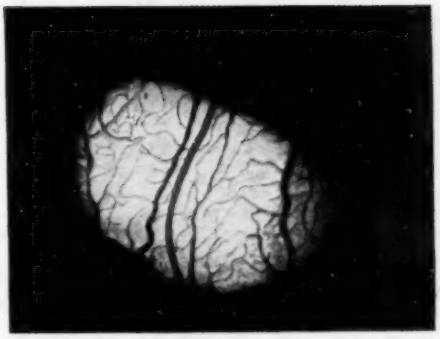

Fig. 5.—Lumière autochrome photomicrograph (magnified × 5), fifteen seconds' exposure, showing general distribution of vessels (under low power) and especially the contrast between arteries and veins.

corpuscles only in single file are numerous. These either join other arterioles or dip down into the cortex and disappear (figs, 6, 7, 8 and 9).

The blood flow in the arteries is ordinarily too rapid to be seen, except in the finest arterioles where under high magnification, the corpuscles can be seen flashing past. When the arterial pressure falls to a low level, however, the flow in many of the arterioles becomes visible, and finally, with a failing heart, the flow in all the arteries is seen. On two occasions, the corpuscles in a small anastomotic arteriole have been

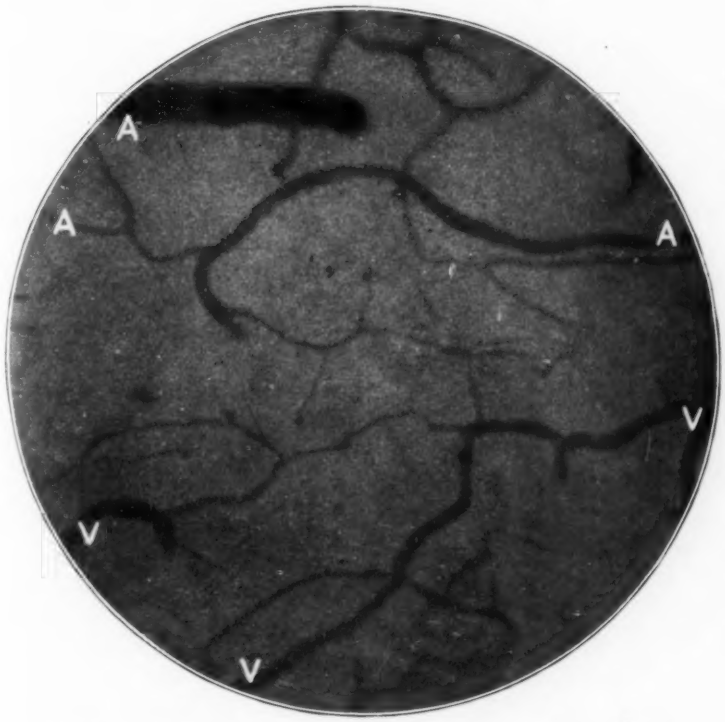

Fig. 6.—Photomicrograph, five seconds' exposure, showing fine arterioles dipping into cortex and venules emerging from cortex and anastomosing with other venules. (Actual magnification, × 75). In this and in the following legends, A and V indicate the arteries and veins, respectively.

observed to slow up, stop, pulsate back and forth, and finally to start off in the opposite direction. This reversal of flow occurred two or three times in ten minutes. No true periodic opening and closing of these minute vessels (as described in the capillaries of the kidney and elsewhere) has been seen. At death, after a few seconds of stasis, a reversal of flow in the larger arteries takes place, the animal being in the posture described and the chest unopened.

In veins of all sizes the flow is clearly visible, the rate varying greatly in different venules. In branch venules the flow often may be seen to stop, pulsate for a few moments and then reverse. In small venules with sluggish flow, the stream often has a pulsating character which persists, clumps of red blood cells pausing and again moving forward with each systole. When the respirations are deep, especially when no tracheotomy has been performed, a periodic slowing and speeding up of the venous flow may be seen; in other words, the effect of a change in intrathoracic pressure, transmitted upward through the jugular veins, is soon apparent

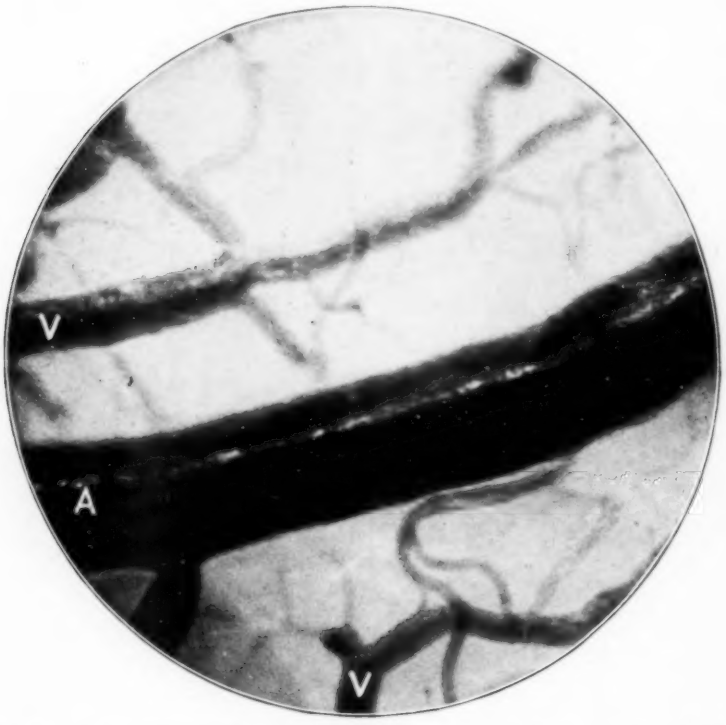

Fig. 7.—Photomicrograph, one second's exposure, of large artery with branch showing the usual constriction at its origin, and two small veins on either side with venules winding under the artery. (Actual magnification, × 60.)

in the venules as a change in the rate of the flow of blood. The change from slow to fast does not appear to be synchronous with the beginning or end of either phase of respiration, but starts at some moment after the middle of expiration and ends after the middle of inspiration. When two veins unite, a clear line of plasma separating the two unmixed streams of red blood cells may be distinguished for some distance in the common vessel.

In the smallest (capillary size) venules emerging from the cortex the flow is rapid, and the corpuscles seem to move in a pulsating stream. In slightly larger venules the flow is slower and entirely without pulsation. Then, as the tributary venules unite and become larger, the flow becomes steadily more rapid, until in the larger veins it is scarcely visible, and it always remains nonpulsating. Corpuscles progressing slowly into a small branch can be seen to be swept suddenly forward as they enter a large vein. This aspirating effect of the larger veins on the smaller was called attention to by F. Fremont-Smith [24] who emphasized the possible

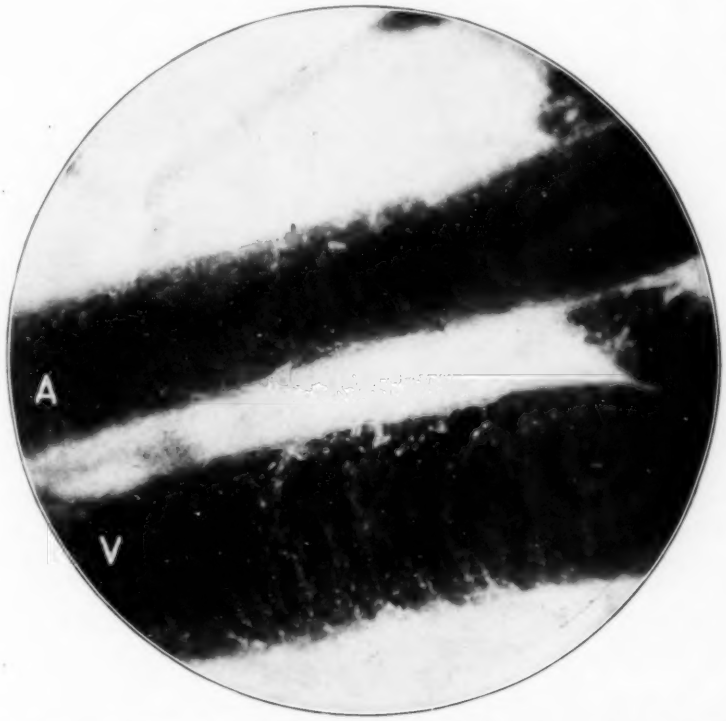

Fig. 8.—Photomicrograph, five seconds' exposure, showing a large artery and vein surrounded by glistening webs of pia arachnoid. (Actual magnification, × 60.)

importance of this factor in the return of blood from the tissues to the heart.

Ordinarily, when measuring the diameter of an artery under uniform conditions, slight if any changes occur, even when the observations extend over an hour or more. Measurements during such periods have been taken at minute intervals and recorded with simultaneous readings of cerebrospinal fluid pressure and systemic arterial pressure.

24. Personal communication to the author.

COMMENT

Use of the method described does not furnish direct data concerning the action of the deeper cerebral vessels. Indirect evidence on this point, however, may be obtained by examining the simultaneous fluctuations in pressure within the subarachnoid space, within the cerebral arteries (using the peripheral end of the carotid), within the systemic arteries (using the central end of the carotid, or the femoral), within the intracranial venous sinuses and within the peripheral veins. The chief diffi-

Fig. 9.—Photomicrograph, one second's exposure, with low power showing irregular dilatations of veins and, to a less extent, of arteries. (Histamine 1/10,000 had been inserted under the window half an hour previously.) Just below the large artery, which lies superficial to the veins as is usually the case, is a dark line caused by red blood cells lying free in the subarachnoid space. Between them and the cells within the lumen of the vessel is a white line representing, probably, the thickness of the arterial wall. (Actual magnification, × 15.)

culties in truly ascertaining what changes occur in the lumens of deep cerebral vessels seem to be the following: 1. The rates of income and outgo of cerebrospinal fluid are unknown. 2. Changes in arterial caliber may parallel changes in venous caliber or they may go in the opposite

direction (or one may change and the other not), variously affecting intracranial pressure. 3. Changes in caliber of large vessels may be accompanied by changes in the same or in the opposite direction in small vessels, so that again alterations in intracranial pressure may fail to indicate the regional change in volume. In spite of these difficulties, it seems reasonable to suppose that when all the surface vessels dilate and the intracranial pressure at the same time rises steeply (as actually occurs in asphyxia), the deep vessels also dilate. Thus the evidence, even if it is not conclusive, may at least indicate the behavior of the deep vessels.

As motion of the brain is not perceptible beneath the tightly sealed window, it is appropriate to discuss the conclusion of Leonard Hill in regard to this. He decided from his experiments that in the normal closed skull there were definite movements of the brain with respiration and with heart beat. The accuracy of his conclusion depends on whether or not the conditions imposed by his experimental procedure were equivalent to a closed cranial cavity. From his detailed description of the apparatus, it is difficult to see how it could be considered a closed system, for he used a manometer with an open end. In such a system, changes in pressure may be readily transformed into movement, and oscillations of an indicator bubble cannot be used as proof of movement of the brain when it is enclosed by the rigid skull. It may well be that the so-called "elastic doors" (occipito-atlantoid ligaments, etc.) give slightly and permit a to and fro movement of the cerebrospinal fluid, but this would not necessarily imply movement of the brain itself.

Within the cranium the velocity of blood flow is probably greater than elsewhere in the body, especially in man in the erect or the sitting position, for under these conditions the intracranial venous pressure is negative (less than atmospheric), and the arterial pressure is relatively high. If this premise of a rapid flow is correct, the decided difference in color between arteries and veins suggests a rapid utilization of oxygen by the brain tissue.

SUMMARY

Apparatus is described for observing the blood vessels of the pia in living anesthetized animals, and for measuring their changing diameters. It consists of a window with a washout system, a head clamp and a specially mounted microscope with micrometer scale. The value of recording at the same time the changes in pressure within the skull and within the blood vessels in various situations is emphasized.

A technic has been developed for making photomicrographs in black and white and also in color. A few observations on the usual appearance of the vessels have been added.

EXPERIENCES WITH ENCEPHALOGRAPHY VIA THE LUMBAR ROUTE *

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Introduction.—This paper is based on observations made in forty-seven cases. Of these, forty-two were studied in the neurologic service of the Mt. Sinai Hospital and five in the neurologic department of the Bellevue Hospital.[1]

HISTORICAL DATA

Dandy, in 1918, first suggested the injection of air into the cavities of the brain for diagnostic purposes, but abandoned the endolumbar for the cerebral method. Since then, however, Bingel, Foerster, Wartenberg, Liberson, Carpenter and others have made use of the spinal method, some of them with the aid of complicated apparatus (Bingel, Wartenberg, Liberson).

TECHNIC

We have employed the lumbar route. The procedure was carried out with the patients fasting. Every one received a preliminary hypodermic injection of morphine (⅙ grain [11 mg.]) and scopolamine (1/200 grain [0.3 mg.]). Spinal puncture was performed in the usual manner but with the patient sitting upright. A two-way valve was then inserted into the lumbar puncture needle. One of the orifices was utilized for the escape of cerebrospinal fluid and the other for the injection of air. The fluid was allowed to drip through rubber tubing into a graduated cylinder. After 10 cc. had been collected, an equal amount of air was injected by means of a syringe attached to the other orifice. This procedure was repeated until either no fluid or very little would issue from the one orifice. During the injection of the air, the head is held extended. Manipulation from side to side and alternate extension and flexion of the head are often helpful in bringing the cerebrospinal fluid down to the subarachnoid space of the cord. Toward

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* From the Neurological Service of Mt. Sinai Hospital.

* Read at the Fifty-Third Annual Meeting of the American Neurological Association at Atlantic City, N. J., May 25, 1927.

1. Since the presentation of this paper at the annual meeting of the American Neurological Association at Atlantic City, eighteen additional patients have been subjected to this procedure and corroborate our observations on its diagnostic value.

the conclusion of the procedure, the air tends to escape. This can be detected by the appearance of tiny bubbles at the mouth of the tube, and is an indication that drainage has almost been completed. In those cases in which the fluid dripped freely, 15 or 20 cc. was permitted to flow off and an equal volume of air was injected, the total varying, on an average, from 90 to 120 cc. It is advisable to inject a smaller volume of air than of fluid withdrawn to allow for expansion of the air at body temperature in the cerebrospinal spaces. In one instance, 175 cc. was injected. Satisfactory roentgenograms were obtained with 35 cc., and in one case even with 15 cc. At the end of the procedure, the patient is permitted to lie down, and the encephalograms are made soon afterward.

PHENOMENA OBSERVED DURING THE PROCEDURE

The symptoms observed are not the result of the removal of fluid; they are due rather to the injection of air. It is then that the patients begin to complain. They speak of pain in the occipital region, especially behind the ears. This is probably brought about by the rushing of air through the foramens of Luschka. At times, pains are referred along dorsal root zones.

The chief symptom is headache, usually localized in the frontal region. Occasionally, phenomena of collapse with marked pallor and profuse perspiration are observed. In such instances, the patient should lie down for a few moments. The symptoms are usually transitory; the patient can soon be permitted to sit up again and the procedure be continued. At first, there is considerable acceleration of the pulse rate. Later, bradycardia sets in. At times, nausea and vomiting occur. Toward the end of the procedure, the patients usually become somewhat drowsy. The accumulation of the air seems to exercise a mild narcotic effect. The nausea, vomiting and bradycardia suggest irritation of the vagus.

In cases attended by syncope, a hypodermic injection of caffeine may be given as a stimulant. The injection of air should be discontinued on the appearance of blood, owing to the danger of air embolism.

AFTER-EFFECTS OBSERVED

One of the after-effects was headache, which persisted on an average from one to three days. It was not any more severe than the headache often observed after simple lumbar puncture and was readily controlled. Some of the patients complained of dizziness. Two of them experienced the sensation of succussion in the head; in three instances, a meningeal syndrome developed, with polynucleosis in the spinal fluid. In one case, the number of cells rose to 19,500. The meningitic phenomena disappeared, as a rule, after forty-eight hours.

There were no fatalities that could be ascribed to the procedure, even when the patient was in poor physical condition. A fatal issue occurred in a patient with amaurotic idiocy. The child presented the signs of an aseptic meningitis forty-eight hours after encephalography and succumbed. However, it had had fever for several days prior to the injection of air. No organism was recovered.

ENCEPHALOGRAMS

The encephalogram should be made immediately after insufflation. At the first examination, anteroposterior and lateral views should be taken. A complete series of plates should be made on the following day. At this examination, the posterior and anterior horns should be studied more carefully, and stereoscopic views of the lateral ventricles should be taken. For the anteroposterior view, the head must be in a direct median position in order to avoid distortion of the skull and shifting of the midline to one side. The Bucky diaphragm should be employed. As a rule, the subarachnoid space can be readily and entirely filled, but the ventricles not so readily. This is well illustrated by figure 14 in case 9.

The most important view is the anteroposterior, as it often gives information concerning the ventricles when the quantity of air is not sufficient to be well visualized on the lateral plate. The interpretation of the pictures requires considerable experience. The air leaves the subarachnoid space almost entirely within from twelve to twenty-four hours unless there is retraction of the brain with external hydrocephalus. It leaves the ventricles in periods varying from three to seven days. In one instance (case 5), in which an operation was performed by Dr. Cushing, air was found in the ventricles nine days after its injection. Large quantities of air remain in the cavities of the brain for longer periods.

The normal encephalogram presents, in the anteroposterior view, the characteristic butterfly-shaped anterior horns of the lateral ventricles, the upper part giving a darker and the lower part a lighter shadow owing to encroachment of the basal ganglia on the ventricles. In the postero-anterior view, one gets a figure resembling a ram's horns. In the lateral plates, if a sufficient volume of air is injected, one obtains casts of the lateral ventricles. The tip of the inferior horn, the third ventricle and the cisterns overlap in the lateral plate. The fourth ventricle appears in the form of a triangle behind the petrous bone. Often the cisterna pontis can be visualized posterior to the pituitary fossa. The air in the cerebral subarachnoid space is usually observed in the form of fine threads coursing through the cerebrum. Lateral stereoscopic plates are often confusing because of incomplete filling of the ventricles.

On the second day, a change is usually noted in the shape of the anterior horns from the butterfly pattern to a more or less rounded form. This is probably to be ascribed to the irritating effect of the air on the choroid plexus, resulting in hypersecretion and the production of a transitory internal hydrocephalus. Frequently, one observes that more air reaches the ventricles after several hours or on the second day. This has been attributed to the pumping effect of the cisterns.

In three cases, though a sufficient quantity of air had been injected, the absence of ventricular air shadows was noted. Similar observations have been made by Foerster, Bingel, Kaufmann and others. There is no adequate explanation for this failure of ventricular filling after lumbar insufflation. It may be that, in such persons, either the foramens

Data of Clinical Material

Tumor of the brain (verified)	18 cases
Tumor of the brain (suspected)	2 cases
Aneurysm of the left posterior cerebral artery	1 case
Epilepsy (idiopathic)	11 cases
Retracted brain	3 cases
Abscess of the brain (chronic)	1 case
Degenerative chorea	1 case
Infantile hemiparesis	1 case
Subdural cyst	1 case
Microcephalic idiocy	1 case
Encephalitic parkinsonian syndrome	1 case
Amaurotic idiocy	1 case
Trauma to the skull	1 case
General paralysis	1 case
Degenerative disease of the brain	1 case
Little's disease	1 case
Hypopituitary syndrome	1 case

of Magendie and Luschka are not patent or the arachnoid villi exercise a ball-valve action. Similarly, Monakow believes that lumbar puncture, by diminishing the pressure in the spinal subarachnoid space, opens up potential foramens.

REPORT OF CASES

The data of our clinical material are included in the accompanying table.

Nineteen of the more instructive cases were selected for detailed analysis.

TUMORS

CASE 1.—*History.*—R. S., married, a housewife, aged 54, was admitted to the Mt. Sinai Hospital, Sept. 1, 1926. The family and previous history were unimportant, except that the patient had had renal colic with hematuria, eight months prior to admission. Four months before, the patient began to suffer from generalized aches and pains which were termed rheumatic. During the two weeks

prior to admission, she felt weakness in the left arm and leg. She dragged the left leg in walking. At the same time, she complained of occipital headache, dizziness and auditory phenomena which she described "as though trains were running." During the week prior to admission, she suffered from incontinence of urine. Hypertension, syphilis or diabetes were not present.

Physical Examination.—There was mental dulness. The left arm was held in partial flexion, and there was disinclination to use the left hand. The optic disks and visual fields were normal. Left facial weakness was present. The deep reflexes were more active on the left side, and a Babinski sign was noted on the left; the abdominal reflexes were equal on the two sides.

Course.—The symptoms progressed, and the patient finally presented a complete hemiplegia with loss of sensation on the left. There was also a suggestion

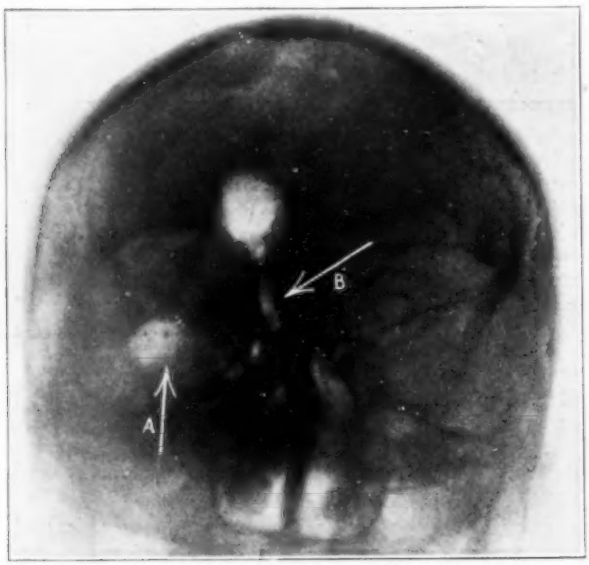

Fig. 1 (case 1).—Encephalographic appearance. The arrow *A* indicates the distended inferior horn and the arrow *B* points to the displaced third ventricle.

of left homonymous hemianopia. Percussion tenderness was present on the right side of the skull, and a suspicious blurring of the disk developed on the right side.

Clinical Diagnosis.—The condition was diagnosed as right temporal neoplasm.

Encephalography.—The encephalogram revealed displacement of the entire ventricular system to the left and dilatation of the left ventricle. There was a small accumulation of air in the right lateral ventricle which manifested itself in the form of a crescent about 6 cm. from the midline (fig. 1). In the stereoscopic plates were also noted an almost complete absence of air on the right, and a well filled left lateral ventricle. Figure 2 illustrates the well filled left ventricle. The clinical diagnosis of a right temporal tumor was confirmed by the encephalogram.

Exploration was carried out, and tissue removed from the depths of the right temporal lobe was reported as showing evidence of a glioma.

The patient died two weeks after the operation.

CASE 2.—*History.*—Saul S., a married man, a renting agent, aged 58, was admitted to the Mt. Sinai Hospital, Oct. 9, 1926. The family history was without significance, and the previous history revealed only angina pectoris for five years. The present illness dated back to June, 1926, when the patient awoke one morning feeling drowsy and weak. The symptoms continued, but he remained at work for three months. At times he saw "halos around the lights." Subsequently, he was not able to continue work because the legs became so weak that he was not able to walk. At times he could not stand. For the week prior to admission he suffered from incontinence of urine. Periodic diplopia was present during the preceding month. Since April, 1926, members of the family had observed weakness, tremulousness, changes in handwriting and speech, emotional instability and

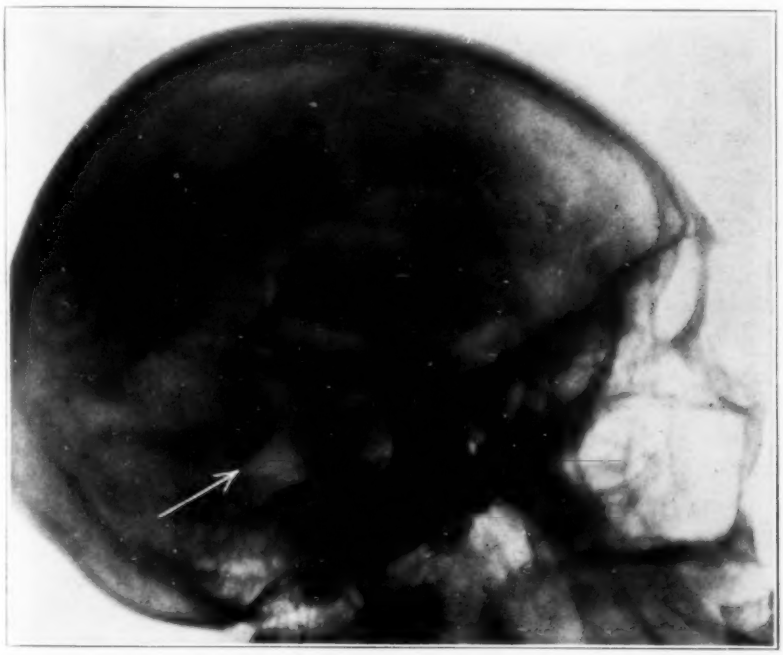

Fig. 2 (case 1).—Well filled left ventricle. The arrow points to the fourth ventricle, which is clearly outlined.

disturbances in equilibration. He seemed to be unable to find his way about in the dark and fell easily.

Physical Exaimnation.—The gait was unsteady with a tendency to hypsokinesis. There was right facial weakness. Some diminution of vibratory sense was noted in the right lower extremity. Mild papilledema was present. The patient also showed clouding of consciousness, irritability, lapses of attention, impaired memory for recent events and a tendency to fill in gaps in memory with silly statements. At times he was facetious. Neither aphasia nor apraxia was present. The visual field could not be tested. At a subsequent examination it was found that the papilledema had increased. Some perioral twitchings were noticed. Speech was dysarthric. There was a hemiparesis on the right with parkinsonian facies, loss of associated automatic movements on the right and a tendency to

retropulsion. Tremor of the extended hands was evident and was more marked on the right. The abdominal reflexes were equal, and there was no Babinski sign. He also showed general dilapidation of personality, a stubborn incontinence and some spontaneous past-pointing inward with the right hand.

Exploratory craniotomy for a suspected deep-seated left temporal tumor failed to reveal the growth.

Caloric tests gave normal responses on the right. On the left, they gave rise to a perverted nystagmus. The left labyrinth seemed less sensitive.

Encephalography.—The encephalogram revealed dilatation of both lateral ventricles. The third ventricle was incompletely filled. Because of the demonstration of symmetrical internal hydrocephalus, the diagnosis of neoplasm in the

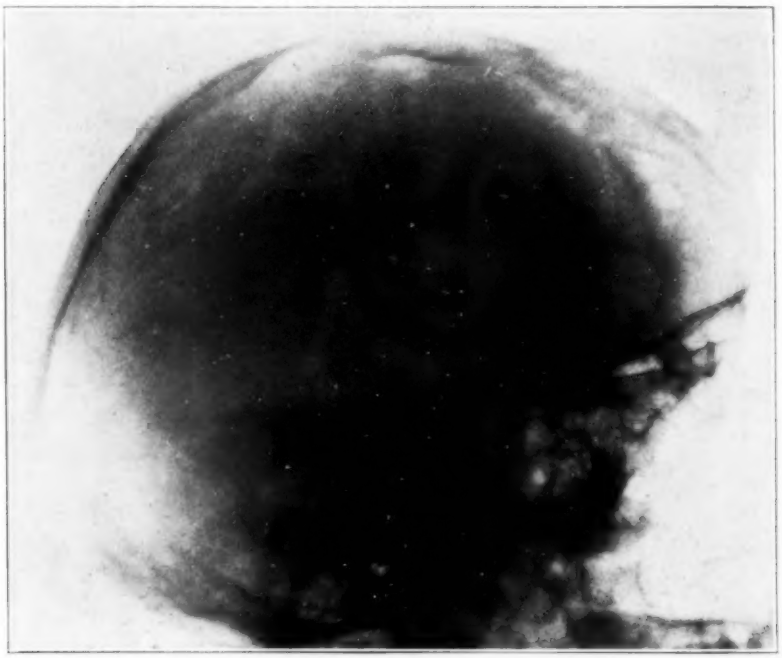

Fig. 3 (case 2).—Encephalographic appearance, showing dilatation of both lateral ventricles.

posterior fossa was made and a suboccipital exploration was performed. The patient survived only a few days.

Necropsy.—Postmortem examination revealed an endothelioma taking origin from the under surface of the tentorium on the right.

Comment.—The clinical history and the objective signs in this case were those of a supratentorial lesion. The encephalogram gave the clue to the true localization.

CASE 3.—*History.*—Sol. R., a married man, a salesman, aged 37, was admitted to the Mt. Sinai Hospital, Oct. 26, 1926. The family history was without significance, and the previous history revealed only a right mastoidectomy in 1912. Hearing had been impaired since then and became progressively worse. He also complained of tinnitus for some time. The present illness began in May, 1925.

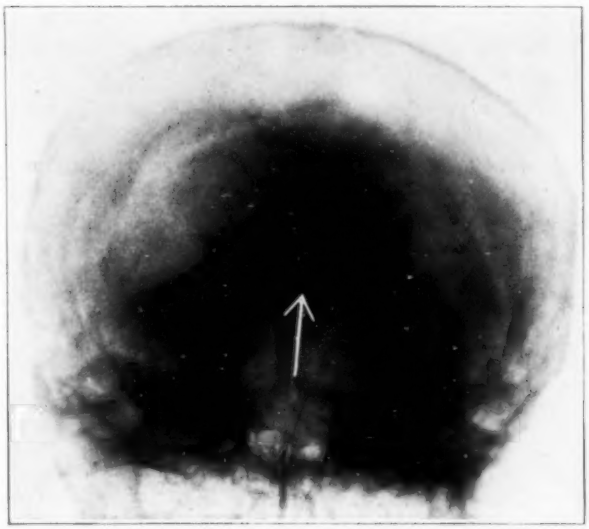

Fig. 4 (case 3).—Encephalographic appearance, showing dilatation of the lateral ventricles and a globular third ventricle (indicated by arrow).

Fig. 5 (case 3).—Encephalographic appearance, showing considerable dilatation of the lateral ventricle.

with vomiting and headache. Vision had deteriorated during the year prior to admission, but had become especially bad during the last three weeks. Gait had been uncertain for six months. During the summer of 1926, the patient saw double for a time.

Physical Examination.—A moderate right hemiparesis with diminished abdominal reflexes but no Babinski sign was present. There was advanced papilledema with pronounced amblyopia. The right ear exhibited nerve deafness.

Course.—A right subtemporal decompression was carried out because of the urgency of the symptoms. Some time later, a left subtemporal decompression was performed without affording relief. Encephalography was then resorted to. It

Fig. 6 (case 4).—Encephalographic appearance, showing a slight shifting of the ventricular system to the right with asymmetry of the ventricles and some depression of the upper pole of the left ventricle.

revealed dilatation of the lateral ventricles and a globular third ventricle (indicated by the arrow in figure 4). Considerable dilatation of the lateral ventricle is shown in figure 5. This patient is still alive, but amaurotic.

Comment.—Cases 2 and 3 both presented evidence pointing to a supratentorial lesion; subtemporal decompression was carried out in both because of inability to localize the neoplasm accurately and on account of the urgency of the symptoms in case 3. Encephalograms were then made, and in both patients a symmetrical internal hydro-

cephalus was found. In the first case, the autopsy revealed the neoplasm in the posterior fossa and in the second case, an atypical acoustic neuroma probably exists.

CASE 4.—*History.*—Jacob C., a married man, a solicitor, aged 54, was admitted to the Mt. Sinai Hospital, Feb. 11, 1927. The family and previous histories were without significance. Headache and dizziness had been present for two months and had been worse during the two weeks preceding admission.

Physical Examination.—The general medical status was normal; the blood pressure was 125 systolic and 80 diastolic. Bilateral low-grade papilledema, more marked on the left side, was found; small hemorrhages were present in the right

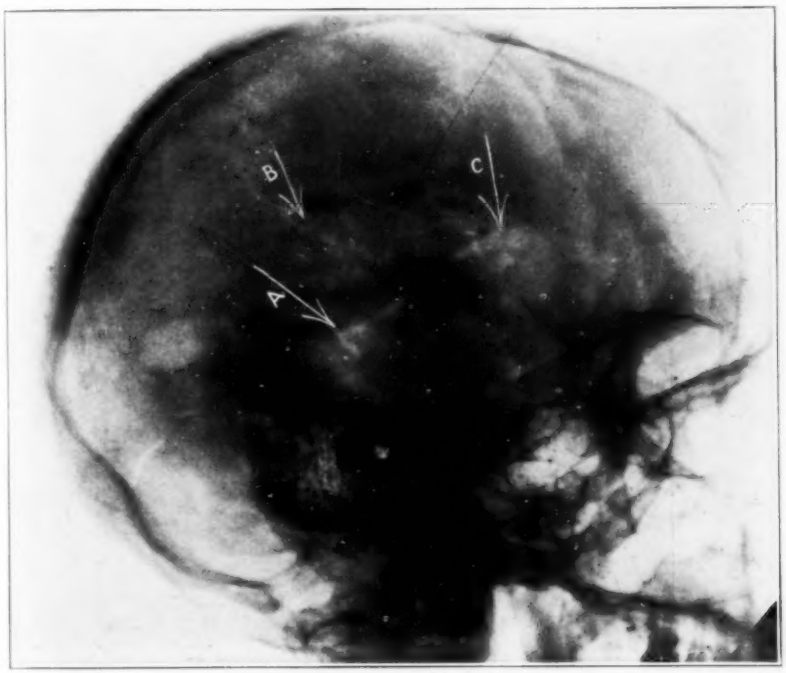

Fig. 7 (case 4).—The depression of the upper pole of the left ventricle shown in figure 6 is indicated by the arrows *A* and *C*. Dilatation of the contralateral ventricle is indicated by the arrow *B*.

fundus. There was slight right facial weakness. The ankle and knee jerks were increased; ankle clonus and diminution of the abdominal reflexes existed on the right; the patient dragged the right leg in walking. He was left-handed.

Clinical Diagnosis.—The condition was diagnosed as left frontal neoplasm.

Encephalography.—The encephalogram revealed a slight shifting of the ventricular system to the right with asymmetry of the ventricles and some depression of the upper pole of the left ventricle (fig. 6). The latter is also shown in figure 7. The contralateral ventricle was dilated. In figure 8, there is a downward dislocation of the posterior horn on the left.

Course.—An exploratory craniotomy was performed ten days later. The patient died nine days after the operation.

Autopsy.—Postmortem examination revealed metastatic tumors of the brain; three nodules were found, the largest being in the left frontoparietal zone. The primary focus was not determined.

CASE 5.—*History.*—F. R., aged 31, married, a housewife, was admitted to the Mt. Sinai Hospital, Dec. 21, 1926, complaining of paralysis of the left leg for two months and weakness of the left upper extremity for two weeks. This condition had been preceded by attacks of vertigo and involuntary twitchings of the left hand for two years.

Physical Examination.—There was left hemiparesis with hyperactive deep reflexes and a positive Babinski sign. The abdominal reflexes were diminished on both sides. Sensory disturbances, headache or tenderness of the skull were not found. The ocular fundi and the visual fields were normal. There were no psychic changes. Serologic examination gave negative results.

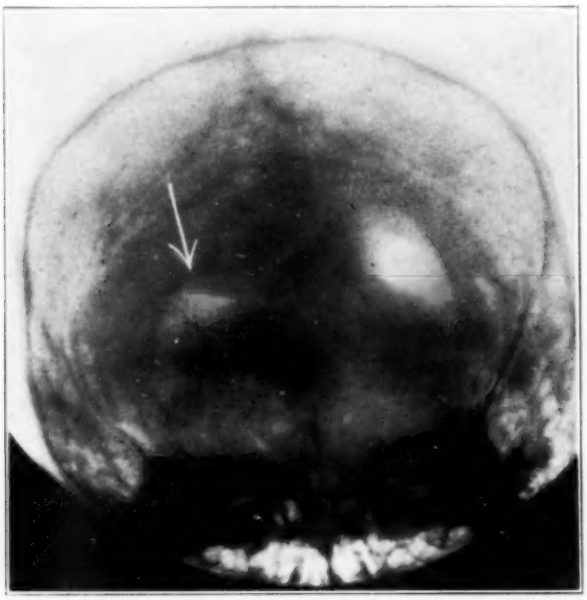

Fig. 8 (case 4).—Encephalographic appearance, showing a downward dislocation of the posterior horn on the left.

Clinical Diagnosis.—The condition was diagnosed as neoplasm of the right motor area.

Encephalography.—The encephalogram revealed a shifting of the ventricular system to the left and asymmetry of the ventricles, with depression of the upper pole on the right. It is interesting to note that the ipsilateral ventricle was dilated in this case, a condition occasionally observed in persons with cerebral neoplasm.

Course.—The patient was operated on by Dr. Harvey Cushing, who found a cystic glioma in the right motor area. Most of the neoplasm was excised. The patient has done well since operation.

CASE 6.—*History.*—George B., aged 56, married, a claim adjuster, who was admitted to the Mt. Sinai Hospital, Dec. 9, 1926, five years before had fallen 35 feet and injured his legs and head. Immediate sequelae did not occur. Five

weeks prior to admission, he developed headache and attacks of dizziness. The headaches began at the base of the skull and radiated forward. There was no nausea or vomiting. The headaches usually became worse at night, when he lay down. For three weeks after the onset, the patient experienced attacks of dizziness which were accompanied by the sensation of a "peculiar sweetish cloud." During these spells, he would have to sit down for fear of falling. For five weeks preceding admission he noted blurring of vision. He felt that his memory was failing and that speech was more slow and cautious.

Physical Examination.—Some emphysema and atherosclerosis were present; the blood pressure readings were 160 systolic; 110 diastolic. The patient was garrulous, euphoric and facetious, and psychomotor fatigability was present. Bilateral papilledema existed and was more marked on the right. There was a left homonymous hemianopia. The pupils were unequal, the left being the larger,

Fig. 9 (case 5).—Encephalographic appearance, showing a shifting of the ventricular system to the left and asymmetry of the ventricles, with depression of the upper pole on the right.

and both were sluggish in reaction. There was left mimetic facial weakness. Disturbances in postural and vibratory sensation were present on the left.

Clinical Diagnosis.—The condition was diagnosed as right temporal neoplasm.

Encephalography.—The encephalogram revealed shifting of the entire ventricular system to the left and dilatation of the contralateral ventricle (fig. 10).

Operation and Course.—Subtemporal exploration was carried out. The diagnosis of right temporosphenoidal neoplasm was confirmed. A hemorrhagic area was found in the right temporal lobe. In its center was a cystlike cavity containing a small amount of detritus. When the cortex was incised, a degenerated neoplasm was seen infiltrating the posterior part of the right temporal lobe. The patient died a week after the operation. Autopsy revealed a spongioblastoma of the right parietotemporo-occipital zone.

Case 7.—*History.*—Israel B., aged 56, a Russian pedler, married, was last admitted to the Mt. Sinai Hospital, March 15, 1927. He was first observed in August, 1924. At that time, the chief complaints were buzzing in both ears and impairment of vision for about two months. Seventeen days prior to admission, he suddenly cried out because of pain over the forehead; he was unable to speak for several minutes. This was followed by twitching of the right side of the body, which continued for an hour. Several hours later, there was a second attack; eleven days later, a third, and the following morning, a fourth. At that time (1924), examination revealed percussion tenderness over the right frontal region and equivocal plantar responses.

The patient was observed a second time in September, 1924, because of recurring seizures. Physical examination then showed weakness of the right grasp,

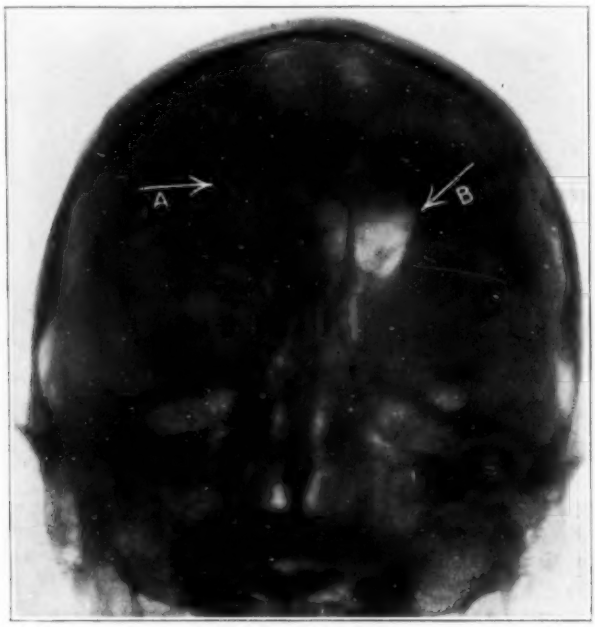

Fig. 10 (case 6).—Encephalographic appearance, showing shifting of the entire ventricular system to the left and dilatation of the contralateral ventricle. Arrow *A* indicates the frontal sinus on the right. *B* points to the dilated contralateral ventricle.

increased deep reflexes and absence of the abdominal reflexes on the right and sclerosis of the retinal vessels with some blurring of the right disk.

He was admitted the third time in March, 1927, on account of headache and jacksonian seizures, as previously described.

Physical Examination.—The patient now revealed: psychomotor retardation with aphasia; increased deep reflexes on the right; deviation of the tongue to the right; bilateral papilledema, more marked on the left, and percussion tenderness over the left side of the skull.

Clinical Diagnosis.—The condition was diagnosed as left frontal neoplasm, low down in the motor area.

Encephalography.—The encephalogram revealed a shifting of the ventricular system to the right with deformation of the lower pole of the anterior horn of the left lateral ventricle.

Operation and Course.—A left frontal operation was carried out. A small area of dense tumor tissue was found in the third left frontal convolution. The patient did not survive the operation. At a postmortem examination, the brain showed evidence of tuberous sclerosis with one nodule in the third left frontal convolution, and a second one projecting into the anterior horn of the left lateral ventricle. The encephalographic manifestations were particularly striking in this case.

CASE 8.—*History.*—Celia P., aged 42, married, a housewife, who was admitted to the Mt. Sinai Hospital, April 15, 1927, had often complained of headache. Eighteen months prior to admission she had a "fainting spell," which was said

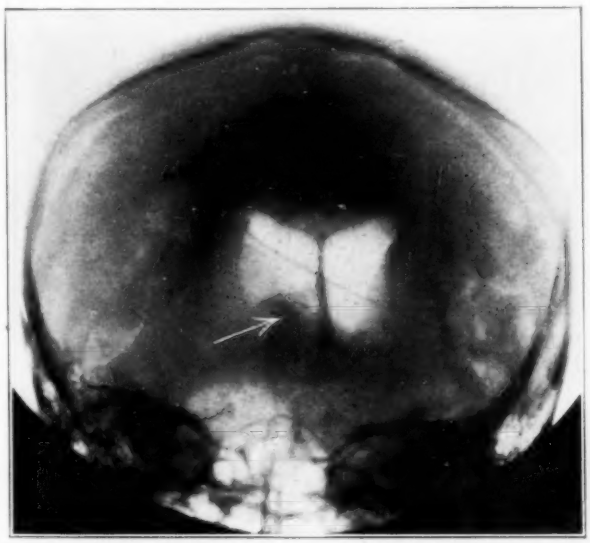

Fig. 11 (case 7).—Encephalographic appearance, showing a shifting of the ventricular system to the right with deformation of the lower pole of the anterior horn of the left lateral ventricle.

to have been accompanied by convulsions. Several months afterward she had a similar attack. Following this seizure, she began to complain of headache and memory became impaired. During the year preceding admission, the patient became more confused, talked incoherently, did not recognize her people, showed incontinence of urine, was helpless and had to be fed.

Examination.—On admission, she was stuporous, incontinent of urine and unresponsive, except for the utterance of a few meaningless words. The general medical examination did not reveal any abnormality. Neurologic examination showed hyperactive deep reflexes, more on the right side, with ankle clonus. While under observation, she developed mild papilledema. She was inaccessible to further tests.

Clinical Diagnosis.—The condition was diagnosed as left sided neoplasm with probable involvement of the corpus callosum.

Encephalography.—This operation was performed on two separate occasions; at the first 65 cc. of air was injected; at the second only 70 cc. of air could be insufflated. The encephalogram revealed occlusion of the left lateral ventricle and a small collection of air on the right in the form of a crescent with its concavity toward the midline.

Operation and Course.—A left sided exploration was carried out. It revealed a subdural cyst with collapse of the brain. Following evacuation of the contents of this cyst the patient improved steadily and has remained well.

CASE 9.—*History.*—Louis G., aged 48, married, a salesman, was admitted to the Mt. Sinai Hospital, March 17, 1927, with frontal headache and left sided weakness which had been present for nine weeks. He recovered somewhat and came to New York from a western city. During the two weeks preceding admis-

Fig. 12 (case 8).—Encephalographic appearance showing occlusion of the left lateral ventricle and a small collection of air on the right in the form of a crescent with its concavity toward the midline.

sion, he again began to drag the left lower limb, became irrational and complained of severe frontal headache.

Examination.—On admission he was in stupor. Physical examination revealed left hemiparesis with signs of involvement of the pyramidal tract and occasional tendency to jocularity but marked unresponsiveness. Papilledema was not present.

Clinical Diagnosis.—The condition was diagnosed as right frontal neoplasm.

Encephalography.—The encephalogram revealed absence of air in the right ventricle, shifting of the ventricular system to the left, an oblique third ventricle and a dilated left ventricle (fig. 13). Figure 14 represents a lateral view (patient upright) with a horizontal fluid level, thereby demonstrating the impossibility of emptying the ventricle of fluid. Incidentally, the fourth ventricle is clearly outlined.

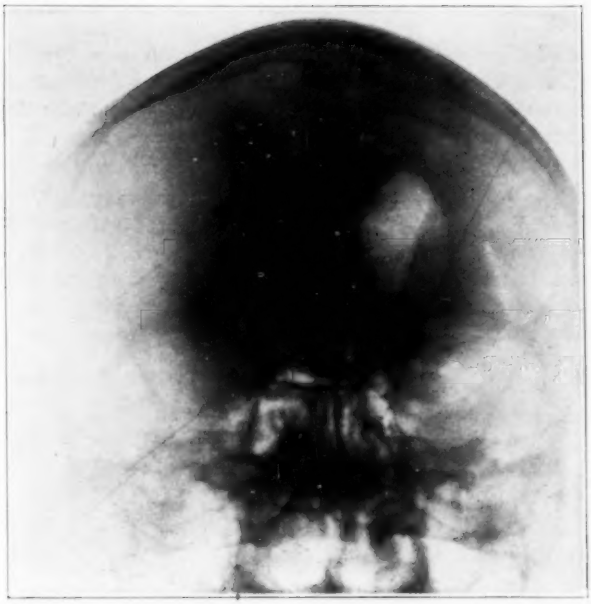

Fig. 13 (case 9).—Encephalographic appearance showing absence of air in the right ventricle, shifting of the ventricular system to the left, an oblique third ventricle and a dilated left ventricle.

Fig. 14 (case 9).—Lateral encephalographic appearance (patient upright) with a horizontal fluid level, thereby demonstrating the impossibility of emptying the ventricle of fluid. The arrow shows the clear outline of the fourth ventricle.

Operation and Course.—A right sided exploration was carried out. The patient did fairly well for a time but died one week after the operation. Autopsy revealed a neoplasm of the right temporal lobe with an area of softening in the left frontal zone.

RETRACTED BRAIN

CASE 10.—*History.*—Frieda Z., aged 48, German, a housewife, was admitted to the Mt. Sinai Hospital, Dec. 24, 1926. She had had smallpox in early life, pneumonia at 25, and a deformity of the left hip since childhood. There was also a history of impairment of memory, blurring of vision and loss in weight. When admitted, she complained of headache and vomiting for six months, with weakness of the right side and difficulty in speech for two months.

Fig. 15 (case 10).—Lateral encephalographic appearance showing a large collection of air in the subarachnoid space (indicated by arrow).

Physical Examination.—There was some weakness of the right side, particularly in the arm, and mild right facial weakness. Signs of involvement of the pyramidal tract were present on the right (sluggish abdominal reflexes, hyperactive deep reflexes and a suggestive Babinski sign). Bradyphasia was present. The disks were normal; the visual fields were intact. Sensory changes and astereognosis were not present. The patient was emotionally unstable and exhibited some difficulty in writing. Serologic studies gave negative results.

Clinical Diagnosis.—The diagnosis lay between a cerebral neoplasm and vascular disease in the midfrontal region.

Encephalography.—In the anteroposterior view, the encephalogram did not reveal any abnormalities in the size or shape of the ventricles, but a large collec-

tion of air in the subarachnoid space was noted in the lateral plates (fig. 15). The subarachnoid collection of air is also shown in figure 16 (occiput up). This led to the diagnosis of a vascular process with secondary shrinkage or retraction of the brain.

Course.—The patient was discharged from the hospital. She was seen a number of months later in the follow-up clinic and appeared to be well.

CASE 11.—*History.*—Rubin S., aged 50, married, a pedler, was admitted to the Mt. Sinai Hospital, Dec. 21, 1926. He had suffered from visual difficulties fourteen years prior to admission, on the basis of a "blood infection." The complaints made were of epileptic attacks for two years, and recently of headache.

Physical Examination.—The patient was illiterate. The right pupil was irregular; both pupils responded well. There was slight flattening of the right

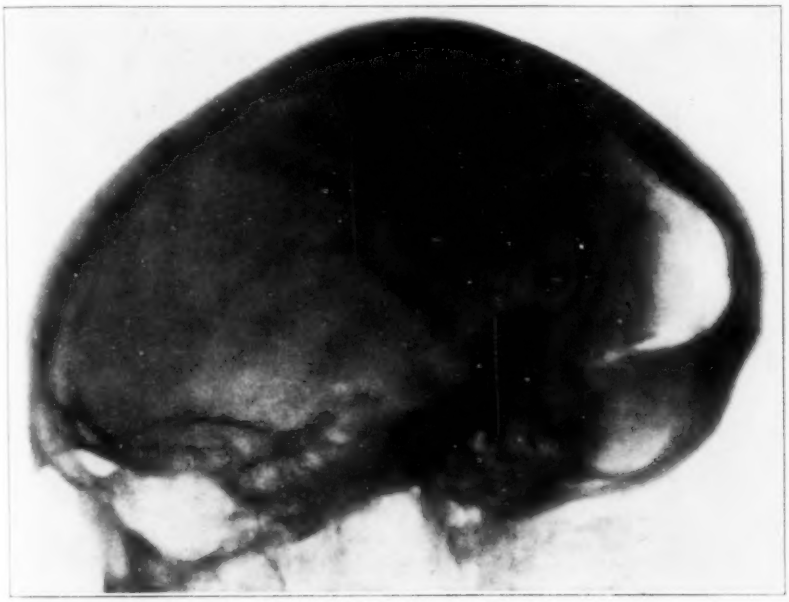

Fig. 16 (case 10).—Encephalographic appearance of subarachnoid collection of air.

side of the face. The deep reflexes were slightly more active on the right side. The right plantar response was suggestively extensor in type. The ocular fundi showed evidence of a postneuritic atrophy. The visual fields were constricted (both for form and color). Serologic examination gave negative results. Roentgen-ray examination of the skull did not reveal any abnormality.

Clinical Diagnosis.—The condition was diagnosed as old syphilis with a focal lesion in the left hemisphere.

Encephalography.—The encephalogram revealed a considerable accumulation of air on the under surface of the brain (fig. 17). Retraction of the brain was also demonstrated by a large collection of air over the convexity. This is clearly depicted in figure 18 (occiput down). It reveals a collection of air anteriorly with a fluid level that is quite distinct, just behind the well filled anterior horn. The encephalographic manifestations led to a diagnosis of vascular disease with atrophy of the brain.

Fig. 17 (case 11).—Encephalographic appearance, showing a considerable accumulation of air on the under surface of the brain (indicated by arrow).

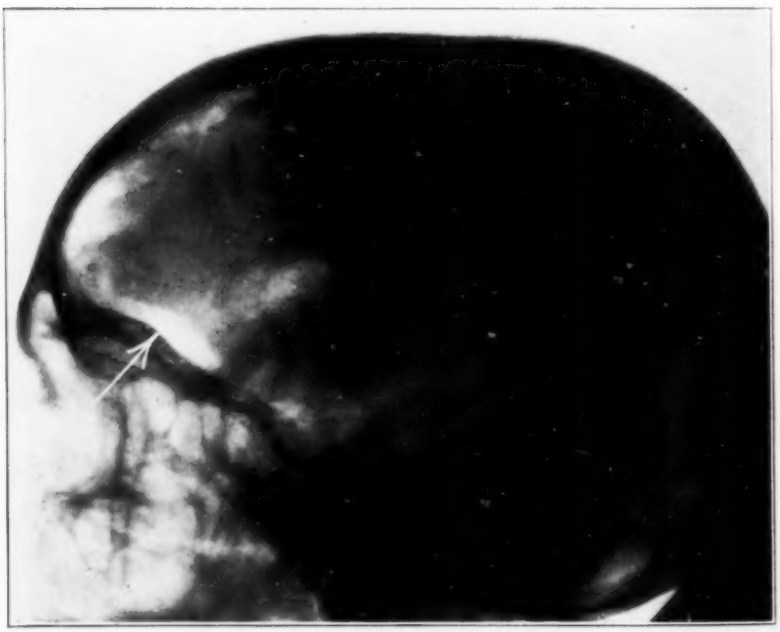

Fig. 18 (case 11).—Encephalographic appearance with occiput down, showing same condition shown in figure 17.

EPILEPSIES

CASE 12.—*History.*—Isidor S., aged 29, single, a civil engineer, was admitted to the Mt. Sinai Hospital, March 15, 1927, with a history of epileptic attacks for three years and failing memory.

Physical Examination.—The heart presented a short systolic murmur at the apex, and tachycardia. Perspiration was profuse. Flushing of the face and tremor, indicative of vasomotor instability, were also noted. The neurologic examination did not reveal any abnormalities aside from diminished knee jerks. Serologic studies gave negative results. The basal metabolic rate was normal.

Clinical Diagnosis.—The condition was diagnosed as idiopathic epilepsy.

Fig. 19 (case 12).—Encephalographic appearance, showing somewhat dilated and rounded anterior horns, a little distention of the third ventricle and considerable accumulation of air in the subarachnoid space.

Encephalography.—The encephalogram revealed somewhat dilated and rounded anterior horns, a little distention of the third ventricle and considerable accumulation of air in the subarachnoid space.

CASE 13.—*History.*—Leah K., aged 65, married, a housewife, was admitted to the Mt. Sinai Hospital, Feb. 26, 1927. She had had postpartum phlebitis at the age of 25, and pneumonia at 42. When admitted, she had had: convulsions for two years, dizziness and headache for three weeks and recent impairment of vision. Two weeks prior to admission she developed severe headache and vomiting. She was left-handed.

Physical Examination.—There was defective conjugate movement of the eyes to the left, with suggestive limitation of the visual fields on the left. The ocular fundi were normal, except for sclerosis of the vessels. The innervation of the

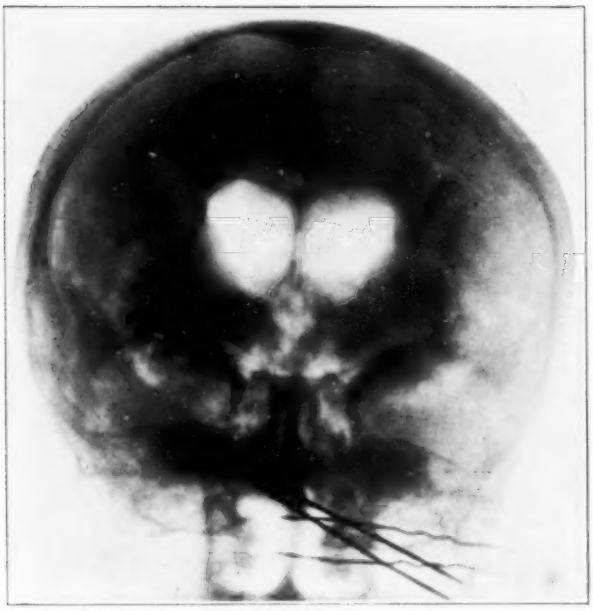

Fig. 20 (case 13).—Encephalographic appearance, showing dilatation of all ventricles and a considerable volume of air in the subarachnoid space.

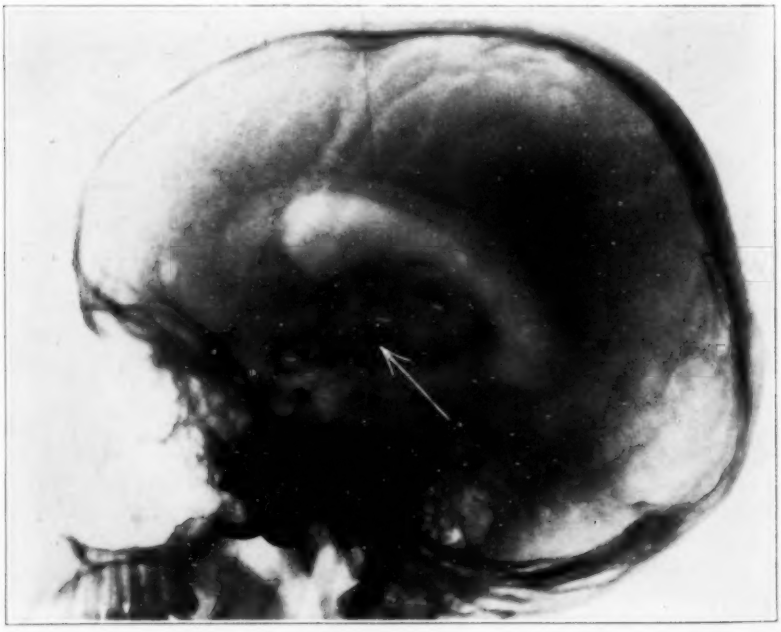

Fig. 21 (case 14).—Encephalographic appearance, showing moderate dilatation of the ventricular system. The arrow points to the third ventricle, which is clearly shown.

left side of the face seemed poor. Slight weakness of the left arm was present. Convulsive seizures continued while the patient was in the hospital. The blood pressure was 140 systolic; 90 diastolic; the urine was normal.

Clinical Diagnosis.—The condition was diagnosed as a focal lesion (?) of the right hemisphere.

Encephalography.—The encephalogram revealed dilatation of all ventricles and a considerable volume of air in the subarachnoid space.

Course.—About a week later, the patient had a convulsive seizure which was followed by left hemiplegia. The fundi still were normal. Lumbar puncture revealed uniformly bloody fluid. She died several days later. Autopsy was not performed.

Fig. 22 (case 14).—In this figure and in figure 21, a considerable accumulation of air in the subarachnoid space is observed.

Comment.—It was thought that this patient presented a generally atrophic brain on the basis of arteriosclerosis with secondary dilatation of the ventricular system and enlargement of the subarachnoid space; the terminal cerebral hemorrhage might have come from a bleeding aneurysm.

CASE 14.—*History.*—Sol. B., aged 13, a schoolboy, was admitted to the Mt. Sinai Hospital, March 2, 1927, with the history that for four years generalized convulsive seizures had occurred with great frequency.

Physical Examination.—General hyperreflexia and slight facial asymmetry, but no other abnormalities were found. Roentgen-ray examination of the skull did not show any deviation from the normal. Serologic studies gave negative results. A ketogenic diet did not improve the condition.

Clinical Diagnosis.—The condition was diagnosed as idiopathic epilepsy.

Fig. 23 (case 15).—Encephalographic appearance, showing symmetrical internal hydrocephalus with dilatation of the third ventricle.

Fig. 24 (case 15).—Encephalographic appearance, showing at *A* and *B* large accumulations of air in the subarachnoid space due to retraction of the brain and widening of the sulci. The third ventricle is also shown.

Encephalography.—The encephalogram revealed moderate dilatation of the ventricular system, well demonstrated in figure 22 (posterior horns). In both figures 21 and 22, a considerable accumulation of air in the subarachnoid space is observed.

MISCELLANEOUS CASES

CASE 15.—*History.*—Louis B., aged 37, Russian, married, a machinist, was admitted to the Mt. Sinai Hospital, Feb. 14, 1927, complaining of nervousness, jerking of the hands and feet and insomnia for three years.

Physical Examination.—Choreiform movements, syllabic speech, generalized hypotonia, mental deterioration, inadequate emotional reactions and failing memory were present.

Clinical Diagnosis.—The condition was diagnosed as degenerative chorea. There was no history of encephalitis.

Fig. 25 (case 16).—Encephalographic appearance showing a "migration" of the ventricular system toward the left.

Encephalography.—The encephalogram revealed symmetrical internal hydrocephalus with dilatation of the third ventricle (fig. 23). Figure 24 depicts at *A* and *B* large accumulations of air in the subarachnoid space due to retraction of the brain and widening of the sulci. The third ventricle is also visualized in this view.

CASE 16.—*History.*—Audrey F., aged 7, was admitted to Mt. Sinai Hospital, March 8, 1927, complaining of convulsions since the age of 18 months. At that time she was dropped on a stone staircase, striking head first. She was unconscious for nine days. One hour after the accident twitchings were observed on the right side. She later developed weakness of the right arm and leg and impairment of speech. The latter gradually improved but is not yet normal. The patient had had convulsive seizures about two or three times a year, with

twitchings at first only on the right side, and later generalized convulsions. Prior to admission, the attacks became more frequent and more severe.

Physical Examination.—Right sided hemiparesis with defective development of the right side of the body was present. Choreo-athetoid movements were observed in the right hand. There were mild pyramidal tract phenomena on the right but no definite Babinski sign. The ocular fundi were normal.

Clinical Diagnosis.—The condition was diagnosed as epilepsy with a focal lesion in the left motor area.

Encephalography.—The encephalogram revealed a "migration" of the ventricular system toward the left (the side of the lesion). The right ventricle was normal in size and contour. The left showed rounding of its upper pole and uniform dilatation, owing to shrinkage and atrophy of the brain.

Fig. 26 (case 17).—Encephalographic appearance, showing a typical external hydrocephalus due to atrophy and retraction of the brain.

CASE 17.—*History.*—Alfred R., aged 5, was admitted to the Mt. Sinai Hospital, Nov. 17, 1926. He had always been dull. Three years prior to admission, a physician was consulted because the patient exhibited stiffness of the legs in walking. This became progressively worse. He also showed increasing intellectual retardation and difficulties in speech. One year prior to admission, he developed convulsive seizures.

Physical Examination.—There was a spastic paraplegia with a tendency to cross-legged progression. The Babinski sign was not present. The ocular fundi were normal. Serologic studies gave negative results.

Clinical Diagnosis.—The condition was diagnosed as spastic diplegia.

Encephalography.—The encephalogram revealed a typical external hydrocephalus due to atrophy and retraction of the brain.

CASE 18.—*History.*—Jeanette G., aged 6 months, admitted to the Mt. Sinai Hospital, April 2, 1927, was a premature infant and weighed 3½ pounds (1,587.58 Gm.) at birth. At the age of 2 months, she would suddenly extend the arms and legs, the face would become blue and she would cry out. It was later observed that she did not respond to stimuli of any kind. Three weeks prior to admission, she had a generalized convulsion. The seizures recurred in the hospital.

Physical Examination.—The head was microcephalic (circumference, 37 cm.). The fontanels were closed. The child was apparently blind and deaf.

Clinical Diagnosis.—The condition was diagnosed as microcephalic idiocy.

Encephalography.—The encephalogram revealed internal hydrocephalus with considerable dilatation of the ventricular system. Air was not observed in the subarachnoid space.

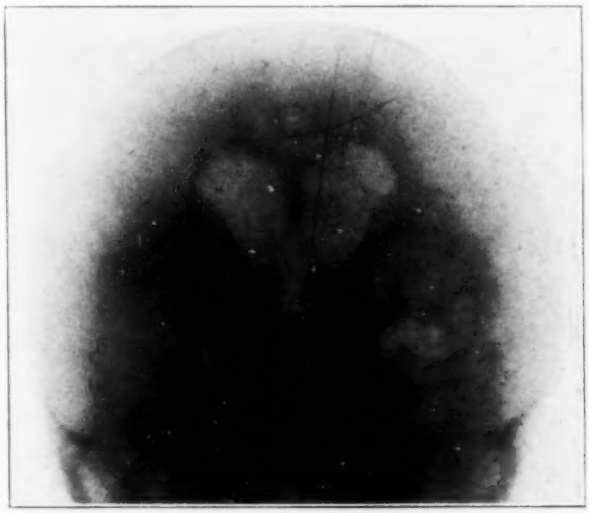

Fig. 27 (case 18).—Encephalographic appearance, showing internal hydrocephalus with considerable dilatation of the ventricular system.

CASE 19.—*History.*—John L., aged 26, a chauffeur, was admitted to the Bellevue Hospital, March 13, 1927, with the history of having been struck on the head in October, 1926. In November, he had a series of epileptiform convulsions which were followed by profound changes in personality.

Physical Examination.—No abnormalities except generalized hyperreflexia were found. A blood Wassermann test proved four plus. The spinal fluid gave a two plus Wassermann reaction; the colloidal gold curve was 3444432100.

Clinical Diagnosis.—The condition was diagnosed as general paralysis.

Encephalography.—The encephalogram revealed considerable dilatation of the ventricular system, more marked on the right, with large accumulations of air in the subarachnoid space over the convexity of the brain. The internal and external hydrocephalus were the result of the cerebral atrophy which is characteristic of general paralysis.

SUMMARY OF CLINICAL OBSERVATIONS

The method described is of great value in the localization of tumors of the brain. It gives evidence of organic disease in doubtful cases and helps to differentiate vascular from neoplastic processes. One is almost tempted to apply this diagnostic method in tumors of the posterior fossa, except when the papilledema is pronounced or clinical evidence indicates jamming of the brain stem.

The method also has merit in persons with trauma for the confirmation of the diagnosis of posttraumatic epilepsy and for the differ-

Fig. 28 (case 19).—Encephalographic appearance, showing considerable dilatation of the ventricular system, more marked on the right, with large accumulations of air in the subarachnoid space over the convexity of the brain.

entiation of traumatic neurosis from "traumatic encephalopathy" (Schwab). In some instances of injury to the skull one finds dilatation of the ventricular system with migration of the ventricles toward the side of the lesion (Ventrikel-Wanderung). The encephalogram is also of importance in differentiating between neoplastic lesions and hysteria or encephalitis.

In persons with tumor of the brain, one encounters a shifting of the ventricular system to the opposite side, a change in the vertical axis of the third ventricle, dilatation of the contralateral ventricle and general distortion of the normal butterfly figure. There may be encroach-

ment on the ventricle from above or from below. The posterior horn may be encroached on by tumors in the posterior fossa, although in our experience it is difficult to make diagnostic inferences from simple distortion or inadequate filling of the posterior horns.

Occasionally, in tumors of the brain the homolateral ventricle is distended, but in such instances there is a shifting of the third ventricle to the opposite side. In internal hydrocephalus, one often finds a characteristic extension of the lateral ventricle, posteriorly, in the shape of a "glove finger."

If one finds normal and symmetrical ventricles, the existence of a cerebral tumor is improbable; if this ventricular picture remains unaltered for months, the presence of a new growth may be excluded. Neoplasms that give few clinical signs—for example, right frontal and temporosphenoidal lesions—often yield striking roentgenographic symptoms.

We have unwittingly performed this test in two cases of subtentorial growth without deleterious results (cases 2 and 3). In both instances a clinical diagnosis of supratentorial lesions had been made. In another case the existence of a neoplasm in the posterior fossa had been suspected, but the encephalographic symptoms were those of a supratentorial lesion. Subtemporal exploration demonstrated the growth. This method was employed in one patient with chronic abscess of the brain without harm. In a number of instances the diagnosis of tumor of the brain was abandoned because of the demonstration of normal ventricles. The encephalogram may permit one to make a diagnosis of cerebral neoplasm early in its course by demonstrating changes in the ventricular system such as have been described.

We wish to call attention to the condition we have designated as retracted brain. This occurred in patients with late epilepsy with symptoms and signs suggestive of focal cerebral disease. Even though the patients did not show evidence of general atherosclerosis, we believe that they presented focal lesions of vascular genesis with consecutive atrophy of the brain. In some of these cases the encephalogram reveals migration of the ventricular system toward the side of the lesion and dilatation of the ipsilateral ventricle. These are the result of shrinkage of the brain on the side of the disease. The mechanical process underlying the ventricular displacement is the opposite of that manifested in persons with cerebral neoplasm, in whom the ventricles are dislocated toward the normal side and the contralateral ventricle is dilated.

Most of the epileptic patients revealed internal or external hydrocephalus or both. The external hydrocephalus was manifested either by extensive accumulations of air at the vertex, at the frontal or at the occipital pole or by larger collections of air in the sulci. The patient with degenerative chorea and the one with general paralysis showed hydro-

cephalus ex vacuo. In the instance of hemiplegia, dating back to early life, the characteristic ventricular migration toward the side of the lesion was noted. The patient with subdural cyst exhibited an absence of air in the left ventricle with a crescentic distortion of the right ventricle. In the microcephalic idiot, we were able to demonstrate, with so small a volume as 15 cc. of air, a definite internal but no external hydrocephalus. The air sought the path of least resistance. This is in accord with the pathologic manifestations in persons with microcephalic idiocy, in whom, as a rule, external hydrocephalus cannot be demonstrated. The procedure was well borne by general paralytic and epileptic patients.

ADVANTAGES OF ENDOLUMBAR OVER TREPHINE INSUFFLATION

1. Lumbar insufflation is not a surgical procedure; it can therefore be carried out by a neurologist in a hospital ward.

2. With the Dandy method it is sometimes difficult to find the ventricles, particularly if they are dislocated.

3. The diagnostician does not have to traverse the brain and is therefore not in danger of striking a vessel and inducing bleeding.

4. By means of endolumbar insufflation one can fill the cerebral subarachnoid space and the cisterns. A better insight is thus obtained into the brain structures.

5. All of the air injected finds its way into the cerebral spaces, whereas, with the Dandy method, the air often escapes beside the needle.

6. There is practically no mortality from this method, and it is therefore a safer procedure.

In favor of Dandy's method, the following points may be enumerated:

1. Fewer subjective complaints on the part of the patient.

2. Absence of meningeal irritation.

3. Less air is required. In a way, however, this is a disadvantage, because one cannot fill all the cerebral spaces.

In persons with obstructive hydrocephalus, the trephine method is the better. One is not justified in making a diagnosis of obstructive disease from the failure of the air to reach the ventricles after lumbar insufflation. In such cases, if air is injected through a trephine orifice, it remains in the ventricles for weeks, indicating the lack of absorptive power of the ventricular walls.

CONCLUSIONS

Endolumbar insufflation of air for diagnostic purposes is a safe procedure. It elucidates many phases of cerebral diagnosis. It is less likely to give rise to serious complications than the injection of air

through a trephine orifice. For persons with well marked tumors of the posterior fossa, however, and for the demonstration of obstructive internal hydrocephalus, the Dandy procedure still remains the preferable method.

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DISCUSSION

DR. TEMPLE FAY, Philadelphia: This method is one of the most important means of diagnosis to the neurologist as well as the neurosurgeon. It can be done at the bedside, and it is important that it should be safeguarded. I might suggest one modification. Frequently, after the fluid is taken out and replaced with a certain amount of air, the patient's pulse may go down rapidly and the respirations become shallow enough to give cause for alarm. For this reason we have been performing encephalograms by a pressure for pressure method, never allowing the pressure to rise above a definite level.

DR. G. H. MONRAD-KROHN, Oslo: About three or four years ago, I used this method in a number of cases in which I suspected the presence of extramedullary tumors. Later I gave it up in favor of ventricular puncture. My reasons for giving it up were these: The patients complained of a great deal of discomfort and I saw several syncopal attacks. There were also quite a few cases in which it was impossible to get any air into the ventricles, when other methods showed that the passage was free, and I came to the conclusion that it was due to a mere chance if the air injected in that way really would enter the foramen of Magendie and foramina of Luschka or pass by.

Concerning the technic, perhaps too little air was injected—much less than was done in the cases just reported. We injected 50 and 60 cc. of air, which may have been too little.

My object in taking part in the discussion is not so much to say what I have just said but to relate an observation which may perhaps be of interest. It was made by two of my colleagues, Dahlstrom and Wideroe. In an extramedullary tumor in close connection with one of the posterior dorsal roots, they could elicit root pains corresponding to the site of the tumor on injecting air by the lumbar route. There have been other cases in which that same sign could be elicited in the same way. This observation, though a "by-product," perhaps after all has some diagnostic value.

When the amount of air that Dr. Friedman and Dr. Kasanin used is injected, can one always be certain that one does get air into the ventricles? Is it not possible that sometimes all of the air goes on to the subarachnoid space of the convexity?

Dr. Charles A. Elsberg, New York: Every one will agree that ventriculography done through a trephine opening has a certain risk and a certain mortality and that this method, already tried in many hundreds of cases, has the advantage that it has not caused any mortality. The performance of ventriculography through a trephine opening is a surgical procedure, while lumbar puncture is much simpler. If the results are just as good by the lumbar injection of air, as far as the roentgen-ray evidence is concerned, as by injections directly into the ventricles, this is the preferable method. In a number of patients that I have operated on after this procedure had been done by Dr. Friedman, the roentgenograms were excellent.

A number of facts have been demonstrated. First, after air has been injected into the lumbar subarachnoid in tumors of the posterior fossa, the air may pass into the lateral ventricle. In several instances when there was a question as to the location of the disease, air injected by the lumbar route entered the lateral ventricles and the roentgenograms showed that the lateral ventricles were widely dilated and that one was dealing with an expanding lesion of the posterior fossa. Secondly, an interesting question, which I know has also been in Dr. Friedman's mind because we have spoken about the matter, is whether in tumors of the posterior fossa lumbar puncture is dangerous if the fluid that has been removed is replaced by air. The method of encephalography by the removal of fluid and injection of air by the lumbar route is much simpler and certainly in a number of instances gives one satisfactory pictures. Whether in most or all instances the roentgenograms are as good and the evidence obtained is as definite as by the direct injection of air into the ventricles will have to be learned by further experience.

Dr. Foster Kennedy, New York: The whole question of performing ventriculograms as a routine matter, as Dandy has advised, has been made difficult by the strain put on the patient and the risk to which the patient is subjected. Many of us have felt that ventriculography as advocated by Dandy, should be used with much discretion because of the danger involved. The work that Dr. Friedman has done and shown here (which he has done in Mt. Sinai and which he did in our wards at Bellevue), I think illustrates that Dandy's objective has been secured and the disadvantages largely eliminated.

There is also the point of view of the patient to be considered. The patient does not differentiate clearly between a diagnostic operation and an operation for cure, and if the operation for cure perhaps has to be done in two stages, he rather resents a preliminary opening of his head. On all counts, I believe that this method which Dr. Friedman has described is a definite advance in the diagnosis of many cerebral conditions.

Dr. Israel Strauss, New York: One might have thought that when we proposed to introduce this method into the hospital, the surgeon would object and say that we were taking away a technical procedure from him, but in this case Dr. Elsberg felt that anything which would relieve the surgeon of an operative procedure preliminary to the final operation was much to be desired, and he cooperated with us in this work. In other words, the neurologist now has a method by which he can go to the utmost along diagnostic lines before he calls the surgeon to his aid to remove the neoplasm, if one is present. This procedure is not attempted if it is thought that a lesion of the posterior fossa is present. We would rather leave that patient alone. This method cannot replace the ventriculographic method of Dandy altogether. For instance, in the case which we reported this method would not have given us the diagnosis that was made by Dr. Elsberg after he had done ventriculography along the lines outlined by Dandy. There are, therefore, cases in which this method will fail. However, in most instances it has been of tremendous help to us.

Just to give an example, in a patient who came into the hospital it was a question whether we were dealing with a softening of the brain or a tumor, in a man of 60. This differential diagnosis is one which all neurologists frequently encounter in practice and which is extremely difficult. The man did not have papilledema; he was doing well after an initial insult to the brain. He acquired a second one and again he regained consciousness and recovered from his multiple paralysis. Dr. Elsberg, seeing the roentgenograms, agreed with us that despite the excellent condition of the patient, he felt that he was justified in making an exploration and looking for a tumor. He did so and a tumor was found.

At present there is a man in the ward of the hospital, who is only 43, with hypertension, chronic nephritis and with a history of a slight cerebral insult affecting the right side, so that one would regard him as having hypertension with probably early arteriosclerosis. He has had a history of headache and vomiting at periods. Choked disk is not present. He is at present extremely euphoric. The roentgenogram shows calcification in the right side of the brain. He has a right hemiparesis. He has, moreover, all the symptoms on the left side of a cerebellar type of lesion. Air was introduced into this man's brain by Dr. Friedman, and it showed a marked dilatation of the left ventricle, probably causing the right hemiparesis; there was almost a complete absence of air in the left ventricle on the side on which the calcific process was present. That, therefore, makes for a rather conclusive diagnosis, despite the bilaterality and dissimilarity of the symptoms, of a tumor low down and far back, that is probably at the junction of the temporal and parietal lobe just at the beginning of the occipital lobe.

I have described two examples in which this method has been of service to neurologists.

Dr. Isador Abrahamson, New York: I wish to stress one advantage of this method. The air that one puts into the spinal canal gets into the ventricles or into the brain. I have seen attempts made at injecting air into the ventricles of the brain, and the air escaped at the time of the injection. One can be sure and one can calculate on the amount of air that one puts in, that most of it will reach the brain and will reach the ventricles.

Dr. Friedman: Due to the limited time at my disposal, I was unable to discuss all the details of our procedure, but may I say in response to Dr. Fay, that the collapse syndrome in these cases was never of long duration. The simple procedure of allowing the patient to lie on his side brings the pulse back at once, and one may continue with the encephalography as planned. Of course,

there may be an advantage in keeping the pressure relations as nearly constant as possible. This technic is not altogether my own. It is similar to the one which I saw applied in the clinic of Professor Förster last summer. We felt that it was therefore unnecessary to devise any elaborate apparatus. This method of encephalography is something which can be carried out in any hospital ward.

The patients suffer from headache, nausea and at times vomiting, but these subside quickly; sometimes the headache will persist for two or three days, but it is never sufficiently severe to be alarming. The patients complain occasionally of root pains, but these disappear promptly. In two instances we have observed meningitic reactions. One of our patients with tumor of the brain presented a severe meningeal syndrome with a spinal polynucleosis of 19,500. The reaction subsided after forty-eight hours.

The failure of the air to reach the ventricles, of which Dr. Monrad-Krohn has spoken, was noted in two or three of our cases. In spite of the fact that we thought we had injected an adequate amount, we were unable to find the air in the ventricles. It is worth noting that this occurs in some cases.

On the first day, we take one anteroposterior and one lateral view. The anteroposterior plate, which, by the way is the most important one, presents in the normal the typical butterfly-shape ventricular system. On the second day, we sometimes find more air in the ventricles and in cases in which none is seen in the ventricles on the first day, we often discover definite air shadows on the second day. This is ascribed by Kaufmann to the pumping effect of the cisterns. Deviation from the normal acquire definite significance, as we have tried to demonstrate.

We have had practically no mortality. We performed encephalography in a patient with amaurotic idiocy who had had a slight temperature for about a week. Following the injection of the air, the child became more stuporous and died three days later, with the symptoms of an aseptic meningitis. I do not believe that it is fair to ascribe the fatality to the procedure, because the child was in poor condition to start with. The fatal termination had not been far off.

We unwittingly carried out this test in two patients with tumor of the posterior fossa. One was that of a man of 50, who presented evidences of atherosclerosis and a history of angina, and who came into the hospital with a right sided Parkinson syndrome. In view of the fact that he revealed low-grade papilledema, the diagnosis of atherosclerosis was abandoned; we felt that we were probably dealing with a neoplasm involving the basal ganglia on the left. In order to confirm the clinical localization, encephalography was performed and to our surprise, a bilateral internal hydrocephalus was found. The diagnosis of supratentorial lesion was then considered untenable and suboccipital craniotomy was performed. The patient survived only a few days. The autopsy revealed an endothelioma of the inferior aspect of the right tentorium, far forward.

In the other case, we had a similar experience. A man came into the hospital with pronounced papilledema and almost complete amaurosis. He presented signs pointing to a lesion in the left hemisphere. Encephalography was performed, and again internal hydrocephalus was demonstrated. This led us to localize the lesion in the posterior fossa. The patient is still alive and is probably suffering from an atypical acoustic neuroma. In cases in which advanced papilledema or clinical evidence of jamming or distortion of the brain stem are not present, one might perhaps cautiously carry out this procedure even in suspected neoplasms of the posterior fossa. The Dandy method, however, will still remain the method of choice in these cases.

This procedure does not lend itself for the demonstration of internal hydrocephalus because one cannot conclude from the failure of the air to reach the ventricles that one is dealing with a closure of the foramina. The Dandy method is preferable in those cases.

I think we have succeeded in demonstrating that encephalography via the lumbar route is a safe procedure; that it can be carried out by the neurologist without the aid of the surgeon; that we do not encounter the risk of injury to the brain with consecutive bleeding as is the case with the Dandy method, and that the information obtained makes it worthy of addition to our diagnostic armamentarium.

THE CEREBELLAR CONTROL OF THE VOCAL ORGANS

AN EXPERIMENTAL STUDY *

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Like most modern ideas concerning the localization of function in the cerebellum, the placing of the laryngeal center in the anterior lobe arose from Bolk's comparative anatomic studies.[1] He said that he was not certain where one should seek for the laryngeal center. Since the larynx arises from the visceral muscles of the head and belongs functionally with the tongue, the pharynx and the other organs of vocalization, he believed that it should be controlled with the bilaterally coordinated muscles of the head in the lobus anterior [2] rather than with the muscles of the neck in the lobulus simplex.

As early as 1904, van Rijnberk [3] checked Bolk's other anatomic conclusions with physiologic experiments and showed that lesions in the lobulus simplex disturbed the functions of the muscles of the neck, and that lesions in crus I of the lobulus ansiformis disturbed the function of the ipsilateral fore limb. Reviews of the physiology and localization in the cerebellum are given by van Rijnberk,[4] Miller [5] and Brun.[6]

Experiments to find the cerebellar center for laryngeal control were not made until 1912, although in 1903 Lewandowsky [7] observed

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1. Bolk, Louis: Over de physiologische Beteekenis van het Cerebellum, Haarlem, 1903; Das Cerebellum des Säugetiere, Jena, 1906.

2. Bolk's terminology is used throughout this paper.

3. Van Rijnberk, G.: Tentavivi di localizzazioni funzionali nel cerveletto: I. Il lobulo semplice, Arch. d. fisiol., 1904, vol. 1, part 5; II. Il centro per gli arti anteriori, Arch. d. fisiol., 1904, vol. 2.

4. Van Rijnberk, G.: Idées actuelles et derniers travaux concernant les fonctions du cervelet, Arch. néerl. de physiol. de l'homme et d. animaux. **10**:155, 1925; Les dernières recherches relatives à la question de la localization dans le cervelet, Arch. néerl. de physiol. de l'homme et d. animaux, **10**:183, 1925.

5. Miller: The Physiology of the Cerebellum, Physiol. Rev. **6**:124, 1926.

6. Brun: Physiologie des Kleinhirns, Schweiz. Arch. f. Neurol. u. Psychiat. **19**:323, 1926.

7. Lewandowsky: Ueber die Verrichtungen des Kleinhirn, Arch. f. Anat. u. Physiol., 1903, p. 174.

disturbances in vocalization with extensive cerebellar lesions in dogs and Brun [6] mentioned similar observations by other early workers. He stated that Lourie observed such disturbances after lesions in the anterior part of the cerebellum and Greggio,[8] after local compression of the cerebellum.

In 1912, Katzenstein and Rothmann [9] performed an extensive series of experiments on dogs in which they showed that section of one or both anterior cerebellar peduncles or lesions in the cortex of the anterior lobe of the cerebellum, especially the lobulus centralis, disturbed the function of barking as well as the motor function of the vocal cords and the tone of the muscles of the jaw and tongue. Lesions in the posterior and middle pedunculi and in the hemispheres and posterior vermis did not produce any such effects. If the lesion was limited to the culmen, the effects were less marked and more transitory than when the lesion extended to the lobulus centralis. The lingula was always spared as a protection to the underlying tissues. Changes in the motor function of the vocal cords were noted by direct observation on animals anesthetized with morphine and ether and were reported to be of the nature of tremors, jerky movements, incomplete adduction and especially the division of abduction into from three to four incremental movements. When one peduncle was sectioned, the disturbances were more marked on the ipsilateral side. The lower jaw was lax and the tongue flaccid. These phenomena persisted for weeks or months but decreased in intensity after the first few days. The dogs did not bark for from one and a half to two months and then the bark was high and metallic. Faradic stimulation of the lobulus anterior with from 70 to 50 R. A. (Rollenabstand) caused raising of the whole larynx, contraction of the muscles of the jaw and strong adduction of the vocal cords. Objective records were not made of any of the observations of Katzenstein and Rothmann, and anatomic examination of the injured brains was not recorded.

Grabower [10] repeated and criticized the work of Katzenstein and Rothmann and concluded that the disturbances observed were all due to the ether anesthesia. He used dogs 1 year of age and while they were under morphine and ether anesthesia observed the movements of the vocal cords; he noted absence of tremors and an adequate abduction and adduction; however, abduction occurred in two, three and four

8. Greggio, Ettore: Intorno alla compressione unilaterale del cervelletto, Memorie I, II and III, Clin. Chir., 1908, 1909, 1910.

9. Katzenstein and Rothmann: Zur Lokalization der Kehlkopfinnervation in der Kleinhirnrinde, Beitr. z. Anat. Physiol. Path. u. Therap. d. Ohres., 1912, pp. 380-389.

10. Grabower: Zur Frage eines Kehlkopfzentrum in der Kleinhirnrinde, Arch. f. Laryngol. u. Rhinol. **26**:17, 1912.

movements as the anesthesia deepened. The operation was performed by entering the skull over the occipital lobe, lifting the lobe, destroying the bony tentorium and injuring the exposed anterior lobe of the cerebellum overlying the fourth ventricle. The movements of the vocal cords were again observed immediately and were exactly similar to those before the operation. Abduction and adduction were still adequate; tremors were not present. Abduction still occurred in two, three and four movements, but this gradually disappeared as the anesthesia became lighter. The dogs were killed at once and the brains examined grossly for the extent of the lesion. One dog was examined on the second day, but the conclusions were the same. Electrical stimulation led Grabower to the conclusion that any effects produced were due to the spread of the stimulus.

Under the direction of Prof. G. van Rijnberk of the Physiological Laboratory of the University of Amsterdam, this work was again repeated with a new surgical approach and with an effort to make more objective observations and records of the movements of the vocal cords and the vocal activities. The anatomic material obtained was studied under the supervision of Prof. B. Brouwer in the neurologic laboratory of the Binnen-Gasthuis.

METHODS OF EXPERIMENTATION

A large number of dogs was examined before any operative work was undertaken. Direct laryngoscopy is readily performed in the dog. The animal is given morphine (5 mg. per kilogram of weight) an hour before the examination. Then it is tied to an animal board and the mouth held open with a Ludwig mouth gag. The tongue and epiglottis are held down with a hinged speculum. Direct sunlight from a window behind the observer, a head mirror and lamp or a flash light may be used. In this way the movements of the vocal cords may be studied for several hours.

In addition to direct observation, two methods of recording the movements of the vocal cords were used. The first was the kymographic method. One end of a pivoted needle was inserted into one vocal cord and the other end bore a reed pointer so placed that the ratio of the length of the needle to the length of the pointer was about 1 : 3. The pointer recorded the movements on a slow-moving smoked drum. The needle was inserted as near the upper end of the true vocal cord as possible or at the insertion of the arytenoid cartilage. This is about the center of the vocal slit in the dog and represents the point of maximum excursion. This procedure proved practical and entirely harmless to the dog.

In a morphinized dog, the needle was introduced under light ether anesthesia; the ether was then stopped and continuous records of the vocal movements were made for two or three hours. Afterward, the dog will bark normally and will not show evidence of injury to the cords. This may be repeated frequently in the same dog without gross injury. Postmortem examination reveals nothing in the vocal cord unless the needle has been placed in the cord on the day of the dog's death, and then only a small point of hyperemia will be seen.

Respiratory movements were recorded at the same time with a Marey tambour tied over the abdomen just below the costal margin. This not only records respiration occurring simultaneously with the movements of the vocal cords, but any movements of the body which occur with struggling or twitching and affords a valuable control in determining the origin of any irregularities in movements of the vocal cords. It was not used in some of the early records, and in these it was necessary for the observer to note when respiration was irregular or when the dog was struggling or twitching and to discard such records.

The second method for recording the movements of the vocal cords was with a cinematographic film. After the dog was prepared for observation it was placed in front of the camera, and pictures of typical movements of the vocal cords were taken for several seconds. A record of the time required was incorporated on the films by exposing a stop watch in the

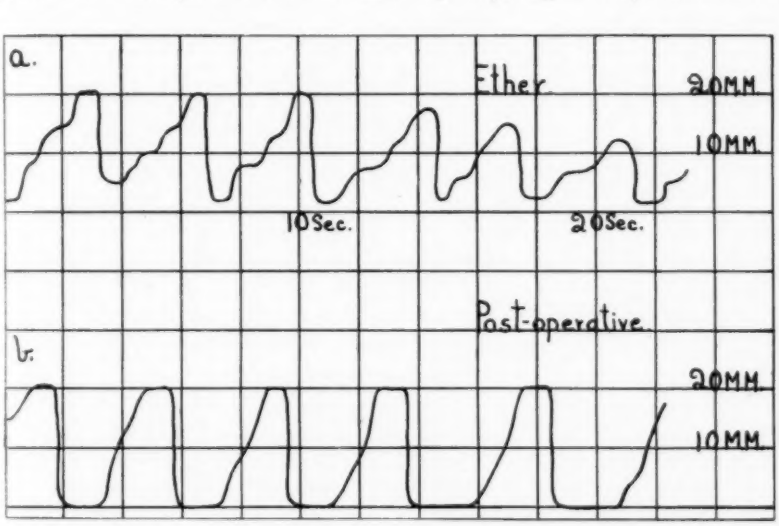

Fig. 1 (dog 23).—Graph of the movements of the vocal cords obtained by the cinematographic method. The movements were normal both before (*a*) and after (*b*) the operation. The movements before the operation were taken under ether anesthesia and show abduction in two and three steps. The ordinate represents one-half the distance between the images of the two vocal cords at each successive exposure in the cinematographic films. These graphs are to be compared with the movement of the left vocal cord shown in the kymographic records (compare with fig. 5*a* and *b*).

field. The space between the images of the two vocal cords at each successive exposure was measured by a low power microscope and a micrometer. One half of this distance—i.e., the range of movement of one vocal cord—was laid off as the ordinate and the time as the abscissa and a graph of the movements so constructed (fig. 1). The curves so obtained corresponded to a satisfactory degree with the kymographic records.

Phonetic studies of some of the dog's vocal activities were also made. For this part of the work I am indebted to Dr. L. Kaiser, lector in experimental phonetics of the University of Amsterdam. Records of both barking and whining

were made on Edison phonograph records and transcribed on smoked paper; the rate was compared to that of a Ut_4 tuning fork—516 vibrations per second—recorded in the same way. One dog (dog 7) was trained to bark on command into the phonograph for the records of barking. For the records of whining, the response of the dogs to discomfort under light morphine anesthesia was used. Only four dogs were so studied; unfortunately, the operative procedures on these four dogs were not successful. Two of them died during the operation; the third showed none of the usual changes in movements of the vocal cords after the operation, and in the fourth, only records of whining had been taken. It is, however, a possible, though laborious, experimental procedure in dogs.

OPERATIVE TECHNIC

The operative procedure was varied from that of previous workers by an effort to avoid the large venous sinuses, the cerebral cortex and the bony tentorium. An attempt was made to approach the lobus anterior through the fourth ventricle. A longitudinal incision was made in the skin from the occipital protuberance to the atlas, and the muscles were separated and scraped from the occipital bone. The occipital bone was opened from the foramen magnum upward for from 1.5 to 2 cm. The dura was incised and the cerebellum elevated by a curved spatula until the lingula could be seen lying between the peduncles. With a curved curet, the lingula and the lobulus centralis were injured. Usually little hemorrhage was present, although occasionally small vessels from the paramedial sulci which crossed directly over to the medulla were encountered and gave some trouble. As a control experiment, an operation was performed on the dorsal surface of the vermis by the direct approach in two dogs.

ANATOMIC STUDIES

Careful anatomic studies were made to determine the extent of all lesions. The dogs were allowed to live eighteen days when possible, as this is the optimum time after which good Marchi preparations can be made. The whole brain was removed and allowed to harden for one or two days in a 10 per cent solution of liquor formaldehydi. It was cut and examined, and the gross extent of the lesions was noted. Then the whole of the cerebellum, medulla and midbrain was prepared by the Marchi technic, and serial sections were cut. Dog 22 died on the sixth day; its brain was prepared by the Weigert-Pal and van Gieson methods. Accurate determination of all primary lesions was made with the microscope, and secondary degenerations were studied as a separate problem.

The age of the dogs chosen for operation is important; a young dog, still possessing its puppy or first canine teeth, will often show uncertain and somewhat irregular laryngeal movements. On the other hand, an old dog whose canines are badly worn will often show more or less tremor of the vocal cords. Dogs with the second canines in good condition will usually show regular, adequate movements of the vocal cords without tremor. Grabower's dogs were 1 year old, and this probably accounts for the uniformity of his observations.

MOVEMENTS OF THE VOCAL CORDS

Normally, under light morphine anesthesia, the vocal cords may be seen to be adducted with expiration and abducted with inspiration. Adduction is prompt and usually complete; abduction may be slower.

At the end of expiration the cords are closed, and this period is usually longer than that during which they are held open. Each is longer than the period actually required for the movement.

If ether is given, there is a marked change in the picture. The movements at first increase in rate and irregularity with the respiration during the period of excitement. If the anesthesia is deep, the cords may be held wide open with the shallow and slow respiration, the movements gradually returning as the anesthesia lightens and the respiration deepens. During the stage of anesthesia just before the reflexes reappear, the phenomena described by Grabower appear. Instead of the usual sequence—quick adduction, pause during closure and fairly smooth abduction and pause during opening—there is a quick adduction with an immediate rebound in abduction; this, however, is only partial, and the vocal cords are held for an instant one-third or one-half abducted; then a second movement of abduction occurs which may complete the opening or may again be interrupted. This is the abduction in two, three and four increments described by Katzenstein and Rothmann as a result of cerebellar lesions and by Grabower as a phenomenon in ether anesthesia. It occurs in any dog under ether and disappears as the reflexes return (figs. 1 and 5*b*).

Every dog that was to be operated on was carefully examined before operation and its age and general condition determined; cinematographic films, kymographic records and direct observations were made of the movements of the vocal cords under morphine. Phonetic studies were made as indicated. Following the operation the general symptoms of the dogs were noted as an indication of the extent and position of the lesion. Morphine was given twenty-four or forty-eight hours after the operation, depending on the condition of the dog, and all observations were repeated. They were again repeated on the following days as often as indicated. The progress of the general condition was observed, and note was made after the first time the dog barked or howled. Protocols are recorded here only of animals in which data of interest to the problem were observed.

PROTOCOLS OF ANIMAL EXPERIMENTS

Dog 23.—*A dwarf pinscher bitch, aged about 3 or 4 years.*

Operation.—On Jan. 14, 1927, the movements of the vocal cords were observed under morphine, and kymographic and cinematographic records were made (fig. 1). The movements were entirely normal. On January 20, the dog was operated on with the intention of producing an injury to the posterior vermis by the direct approach. The operation was without complications. After the operation symptoms were not noticed: forced movements, nystagmus, weakness of the limbs and ataxia were absent. The dog barked normally. On the second day, the vocal cords were again observed, and their movements recorded as before under morphine (fig. 1). Again the movements were entirely normal.

Accessory movements or irregularities were not present. The dog was killed on the eighteenth day. No effect of the operation had been noted other than the healing wound on the back of the neck.

Postmortem Studies.—The brain was fixed in a 10 per cent solution of liquor formaldehydi; it was cut and examined after fixation. Externally, changes could not be seen except a clear circumscribed lesion in the vermis of the cerebellum in its posterior part, apparently in the tuber. Frontal sections through the whole brain did not show any other lesion. The cerebellum and brain stem were prepared by the Marchi technic and serial sections cut.

Microscopic study showed that the only lesion was in the posterior vermis, including the tuber and pyramis. The photomicrograph of a frontal section through this part and the schematic picture drawn on the mesial plane show the extent of the lesion (fig. 2). The point of greatest injury was in the tuber, in which there was destruction of several of the superficial lobuli with their white centers. There was a strip of normal tuber on the oral side adjacent to the lobulus simplex, which remained untouched. But the injury extended caudad over the upper part of the pyramis where the lesion was more superficial and involved only slight injury to the exposed cortical layers of the most superficial lobuli. The lesion was on the left side of the pyramis and was limited, but passed through the center of the tuber and involved nearly the whole width of this lobule.

Comment.—The results with this animal agree closely with those of Ingvar [11] with rabbits. He produced lesions in this part of the cerebellum—which he designated as the lobulus medius medianus—and did not obtain any symptoms.

Nearly all the dogs in this series of experiments showed some injury to this part of the cerebellum after death due to the operative exposure and the position of the healing wound. This dog affords a control for such injuries.

Dog 11.—*A male fox terrier, aged about 4 or 5 years.*

Operation.—On direct observation there was a slight tremor of the back of the tongue, epiglottis and vocal cords. Kymographic records taken on Dec. 8, 1926, showed normal movements of the vocal cords.

On December 10, the dog was operated on by the direct approach to the anterior lobe. The operation was without complications. On the next day nystagmus, forced movements, rolling, rotating or other unilateral symptoms were not present. Both fore legs were weak, and there was a tendency to hold them in a position of "military salute." On the second day this was seen only in the left fore leg, and after that was no longer observed. There was also a marked intention tremor of the neck; this, with the weakness of the fore legs, persisted for some days. The hind legs were always normal. On the tenth day, the dog ran about normally and barked normally on the eleventh day.

Movements of the Vocal Cords.—The movements of the vocal cords were observed and recorded under morphine anesthesia on the second day and were noted as somewhat uncertain and tremulous, but accessory movements were not present.

Postmortem Studies.—The dog was killed on the twentieth day and the brain placed in 10 per cent solution of liquor formaldehydi. It was cut and examined after hardening, prepared by the Marchi technic and cut in serial sections.

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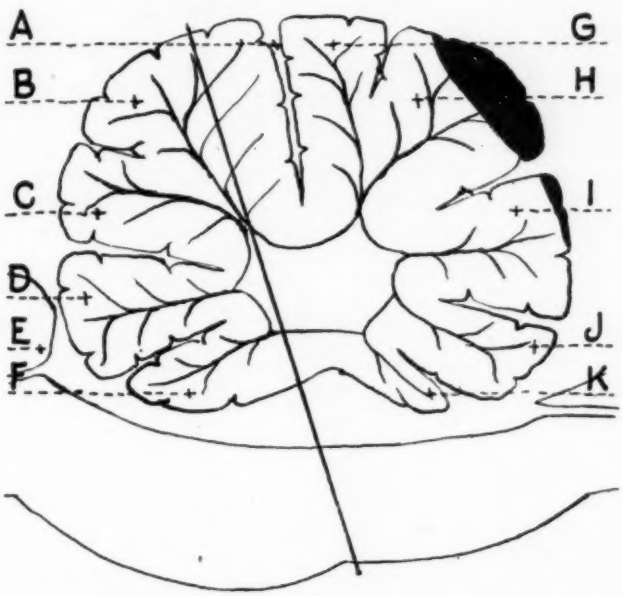
11. Ingvar, Sven: Zur Phylo- und Ontogenese des Kleinhirns nebst einem Versuche zu einheitlicher Erklarung der zerebellaren Funktion und Lokalization, Folia neurol. **11**:429, 1918.



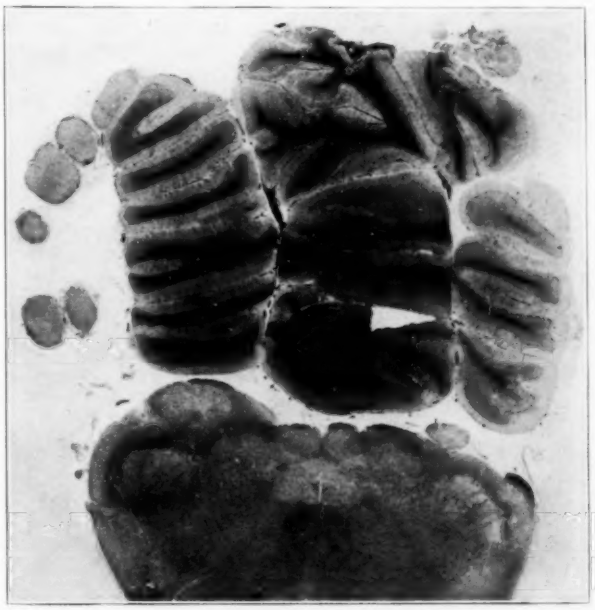


Fig. 2 (dog 23).—A schematic diagram through the cerebellum drawn in the mesial plane to show the extent of the lesion, and a photograph of a frontal section through the level of the maximum lesion in the tuber. The diagonal line in the schematic diagram indicates the plane on which the serial sections were cut. In this figure and in figures 3, 4, 7, 10, 12, 13, 14, 16 and 17, *A* indicates s. primarius (Bolk); *B*, monticulus; *C*, declive; *D*, l. centralis; *E*, c. quad. post.; *F*, lingula; *G*, l. simplex (Bolk); *H*, tuber; *I*, pyramis; *J*, uvula and *K*, nodulus.

There were numerous adhesions betweeen the dorsal surface of the vermis and the wound. Externally, the cerebellum presented a gross lesion in the culmen and a more superficial one extending from the main lesion over the lobulus simplex in the midline and over the tuber. Frontal sections showed the chief lesion in the vermis at the level of the culmen just below the border of the cerebrum. A small black area of blood was also noted in the more dorsal part of the vermis.

A microscopic study showed that the main lesion was in the cortex of the monticulus of the culmen (fig. 3). Beginning caudad at the sulcus primarius, it extended forward just to the first of the lobuli of the declive. Those lobuli which were hidden in the sulcus primarius were not involved, but all other lobuli of the monticulus were injured in the midline. The lesion was about 6 mm. wide and extended into the ventral third of the white tracts, but was far removed from the roof nuclei. The lesion in the most caudal part of the declive was slight and superficial and did not involve the layer of Purkinje cells.

An additional lesion was found caudad to the sulcus primarius, extending in the midline over the lobulus and tuber and touching the upper surface of the pyramis. This lesion slightly involved the mesial edge of the left lobulus paramedianus, but not the right. This was an accidental lesion being, at least in part, due to the adhesions which developed between the exposed cerebellum and the overlying wound. However, there was some actual destruction of the exposed cortical layer of the most superficial lobuli of the lobulus simplex and the upper part of the tuber. In the lobulus simplex below the cortex in the upper surface of the white tracts, there was an area of extravasated blood about 3 mm. in diameter.

Dog 18.—*A young, lactating, German shepherd bitch.*

History.—The movements of the vocal cords were observed and recorded by the cinematograph and kymographic methods on January 7 and 10. It was noted that the movements of the vocal cords stopped nearly or entirely in abduction when the dog was asleep under morphine, even when the respirations were deep. Although the movements were slight, they were regular and steady.

Operation.—The dog was operated on, July 11, and immediately after the operation had violent forced movements, throwing itself about in all directions. The next morning, it was still showing these movements, but they were in a definitely backward direction. It would throw up its right paw and then attempt to throw the whole body backward. There was no tendency toward rolling or rotating nor any difference in tone between the two sides of the body. Nystagmus was not present.

Course.—After twenty-four hours, the forced movements stopped. On the second day the dog was able to stand on all four legs, but was weak and unsteady, and there was an anteroposterior swaying of the whole body with a tendency to fall backward. Unilateral symptoms were not present. There was marked intention tremor of the head and neck when it attempted to drink. It barked normally on the ninth day and growled earlier. It was still a little unsteady on its feet when it was killed on the eighteenth day.

The movements of the vocal cords were observed and recorded on the second and seventh days after the operation. Both times the movements were in all respects similar to those before the operation. There was little movement with normal respiration when the dog was at rest. When movements occurred, they were slight, regular and steady. Accessory movements did not occur. The strength of the jaw was noted to be good.

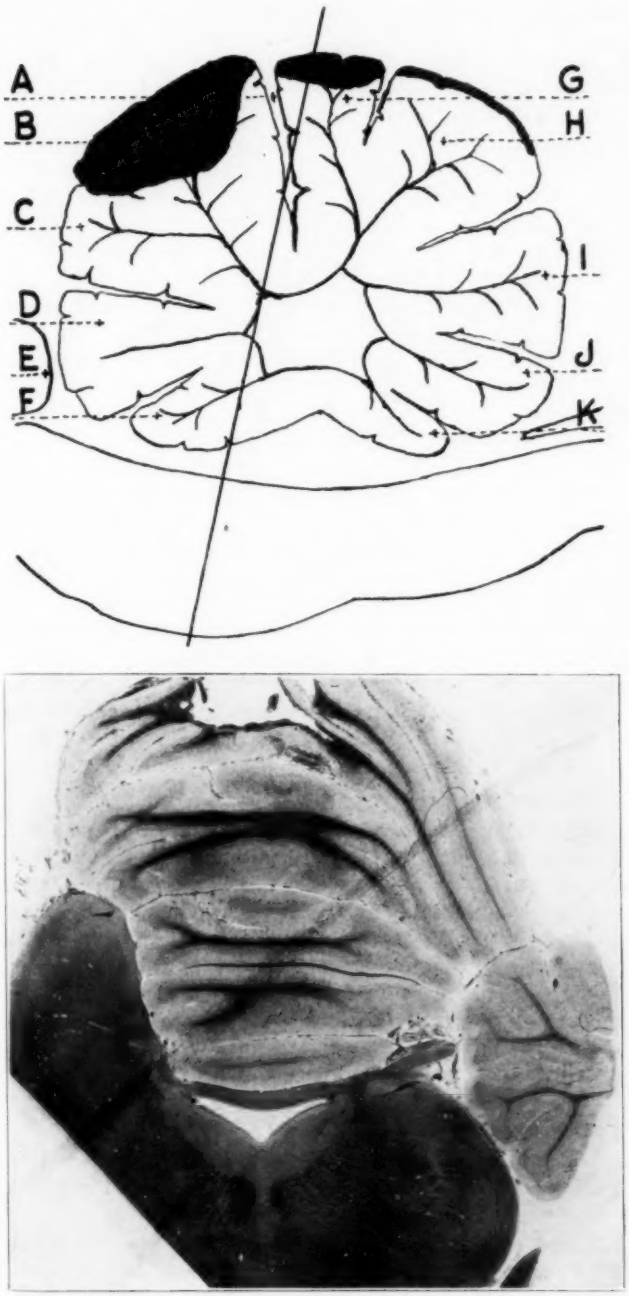


Fig. 3 (dog 11).—Schematic diagram of the cerebellum in the mesial plane to show the extent of the lesion, and a photograph of a frontal section at the level of the maximum lesion in the monticulus.

Postmortem Studies.—The brain was fixed in a 10 per cent solution of liquor formaldehydi and was cut and examined after hardening. Externally, only a slight disturbance over the vermis at the level of the tuber was seen in the cerebellum. Blood was not present in the fourth ventricle. Frontal sections through the cerebellum and medulla showed a definite lesion in the cerebellum, in the midline and passing between the cerebellar nuclei.

Microscopic study of the serial sections showed that the chief lesion was large, passing transversely through the cerebellum from the ventricular surface of the pyramis through the central white tracts and nuclei and through the lobulus centralis almost to its ventral surface (fig. 4). As the lesion entered the pyramis it destroyed only a portion of the cortex, mostly on the right side; as it passed mesially, the whole of the white tracts and the adjacent cortex of all of the pyramis except the most oral lobuli were destroyed, including those tracts which connect the lobulus paramedianus with the pyramis. On the ventricular surface there was also a slight lesion on the mesial edge of both paramedial lobuli; this, however, never involved the layer of Purkinje cells. The upper cortical surface of the lobuli of the uvula, which are in contact with the pyramis, was also injured. Passing mesially, there was a fairly severe lesion of the ventral part of the medulla of the cerebellum involving both the right and the left nuclei fastigii and the left nucleus globosus and nucleus emboliformis. The nucleus dentatus appeared to be intact. Part of the tracts overlying the roof nuclei were also injured. From this point forward, the lesion became smaller. However, it appeared to involve, in the midline, the tracts of the lobulus centralis and at least the oral half of the culmen, but it had a somewhat limited lateral extent so that it appeared that many of the fibers of the lobulus anterior which were not in the midline had escaped damage. The lesion did not reach the ventral surface of the lobulus centralis and its end was placed more caudad than orally and more to the left than to the right. An additional small lesion was seen in the fasciculi of Goll and Burdach on the left side just below the opening of the fourth ventricle.

Dog 7.—*A mongrel English terrier bitch.*

History.—This dog was under observation for more than two months before the operation. During this time, the movements of the vocal cords were observed and recorded by the different methods several times while the dog was under morphine anesthesia (fig. 5*a* and *b*). On all occasions, the movements of the vocal cords were entirely normal.

The dog was trained to bark into a phonograph, and a transcription of the records so obtained is seen in figure 6*a*. Phonograph records were also taken of its whine under morphine as seen in figure 6*d*. It was also trained to lie down on command, to shake hands with the right fore paw and when tied by its collar to reach with either paw for candy which was placed on the floor beyond the reach of its mouth. The latter trick was intended for use as a parallel to the Bárány past-pointing test.

Operation.—The dog was operated on, Jan. 27, 1927, an effort being made to injure the lobulus centralis. Approach was made through the fourth ventricle. The operation was without complications.

Results.—Forced movements did not occur. The dog would lie on the right side, and on the first day if placed on the left side, would roll over to the right. There was a transitory horizontal nystagmus with the quick component to the right. The animal was unsteady on its hind limbs and would fall backward if it attempted to rise. At this time, it did not fall more frequently to one side than to the other, and whirling or rotating was not noticed. The fore limbs appeared

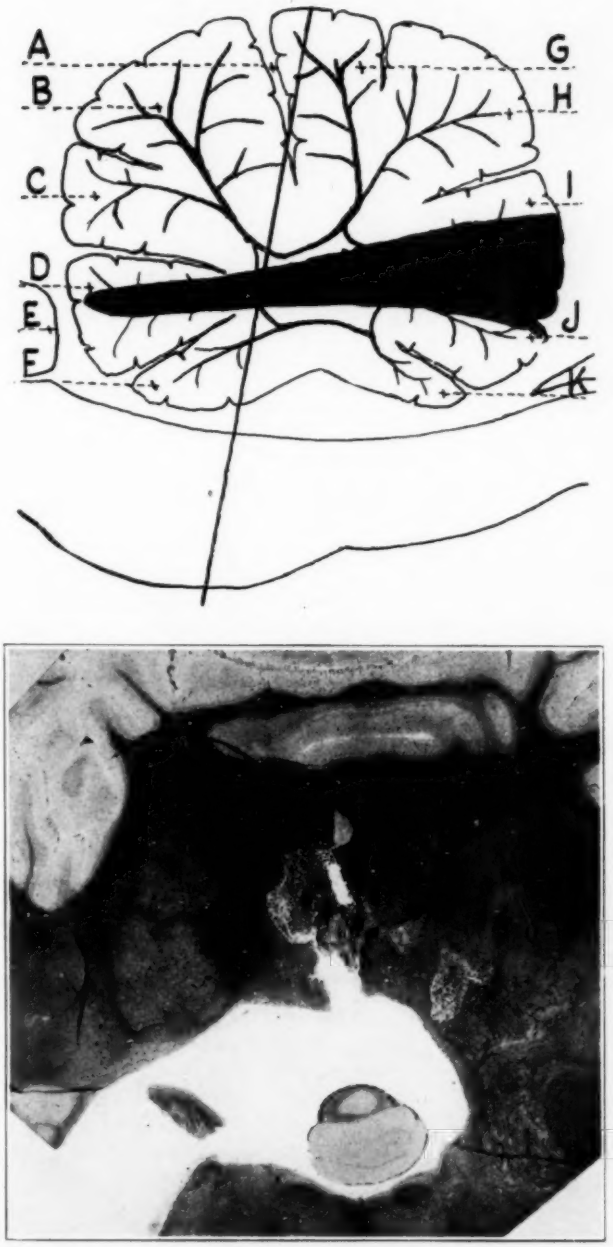


Fig. 4 (dog 18).—Schematic drawing of the cerebellum showing the extent of the lesion, and a photomicrograph at the level of the roof nuclei.

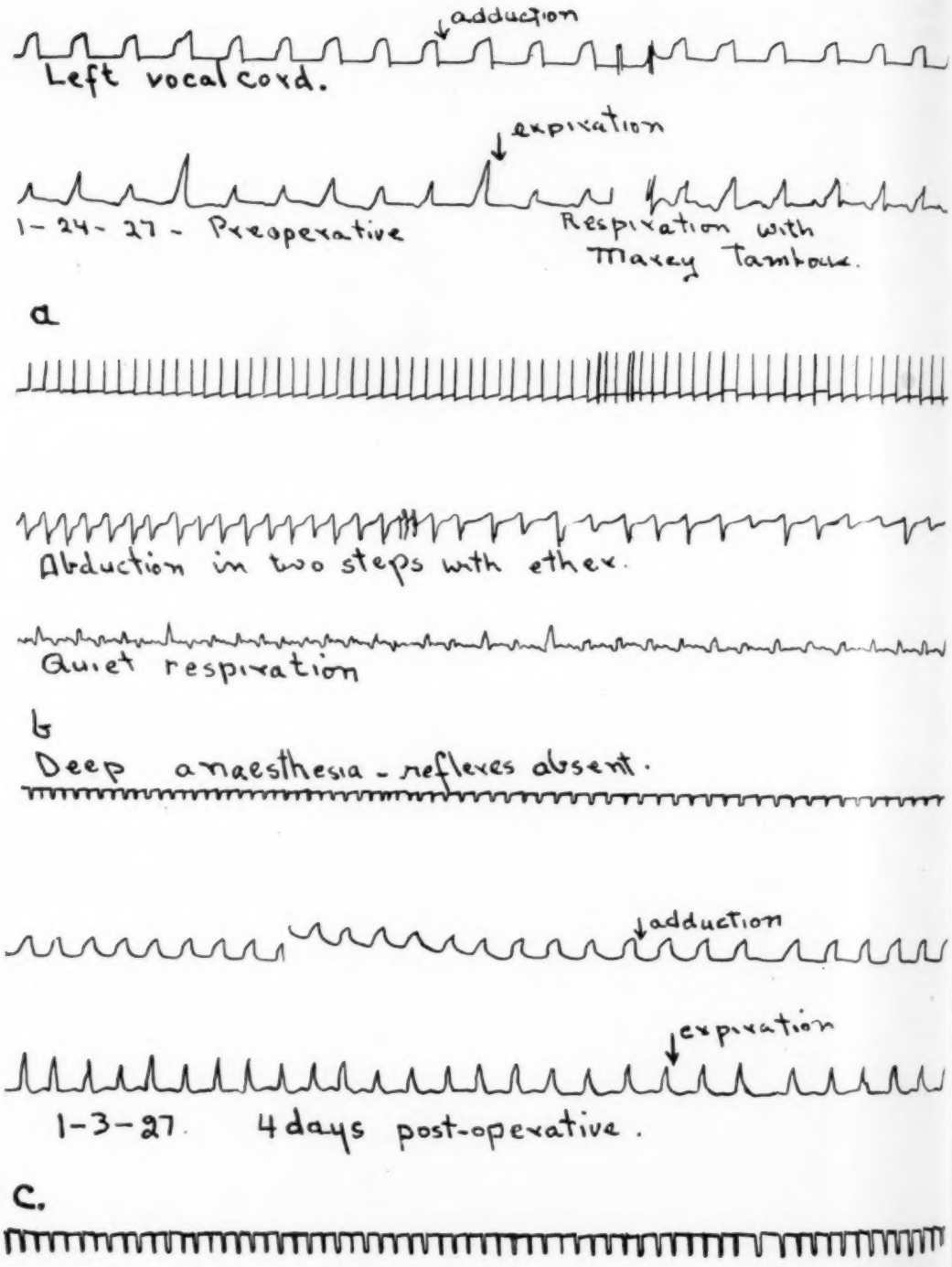


Fig. 5 (dog 7).—Movements of the vocal cords recorded by the kymographic method. *a* shows the normal movements before the operation; *b*, two-step abduction under ether anesthesia before operation, and *c*, normal movements after operation on the anterior lobe of the cerebellum.

normal. It would still shake hands with the right fore paw and would reach for candy with either fore paw without past-pointing.

On the fourth day, the movements of the vocal cords were observed and recorded under morphine by the kymographic and cinematographic methods (fig. 5*c*); they were found normal in all respects. The muscles of the jaw were noted to be strong.

On the fifth day, the dog barked for candy. This barking seemed to require great effort and sounded somewhat like a howl. A phonograph record was made, the transcription of which (fig. 6*b*) shows a record more simple than that obtained before the operation and also more like a whine. There was nothing specific in the change, however, and it might easily have been due to general weakness, especially in the respiratory muscles, and to the fact that the dog could no longer brace itself with the hind legs as it had been accustomed to do when barking before the operation. The bark gradually returned to normal, as will be seen by the record in figure 6*c* which was taken on the twelfth day.

The condition of the animal improved rapidly so that it soon ran about, but the hind legs remained somewhat weak, especially the left one, which would frequently give way and cause a sidling gait to the left. When the dog attempted to jump up or look up, it would fall backward and to the left. The muscles of the pelvic girdle and of the lower part of the abdomen appeared atonic, giving a queer, lank effect to the hind part of the body. The falling backward seemed to be due to weakness of the hind leg and the muscles of the back rather than to a loss of the sense of equilibrium. Abnormalities of the movements of the vocal cords were not observed or recorded at any time, although the dog was studied on several occasions.

Second Operation.—Since the symptoms seemed to be confined to the posterior part of the dog's body, it seemed reasonable to suppose that a severe lesion was not present in the anterior part of the cerebellum. With this in mind an effort was made to reoperate on the eighteenth day after the first operation; this proved too difficult on account of the disturbed anatomic relations and the presence of granulation tissue.

The dog died during the night of medullary injuries and intraventricular hemorrhage.

Postmortem Studies.—The brain was placed in formaldehyde. It showed a considerable amount of hemorrhage in and about the fourth ventricle. A piece of bone wax, about 2 mm. in diameter, was found lying over the tuber. Bone wax was used at the first operation only.

After fixation, the brain was cut and examined. Externally, considerable blood was seen lying on the posterior part of the cerebellum and on the floor of the fourth ventricle. Blood was also seen between the cerebellum and the pons on the right side. This was fresh blood and must have been extravasated at the second operation which was performed twelve hours before death.

There may have been a lesion in the medulla oblongata in the dorsal part of the fourth ventricle, but this region was covered with blood, and this was not certain. Section through the level of the corpus restiforme showed a large clot in the fourth ventricle; anterior to this there was much less blood and the lesion of the first operation could be distinguished from that of the second as the first was in a more dorsal position in the cerebellum, passing into the anterior lobe.

Microscopic study of the serial sections showed that the lesions of the first and second operations involved the same area in the caudal end of the inferior vermis only; in the mesial half of the uvula and pyramis they separated, the lesion of the first operation passing more dorsad through the center of the cerebellum and the

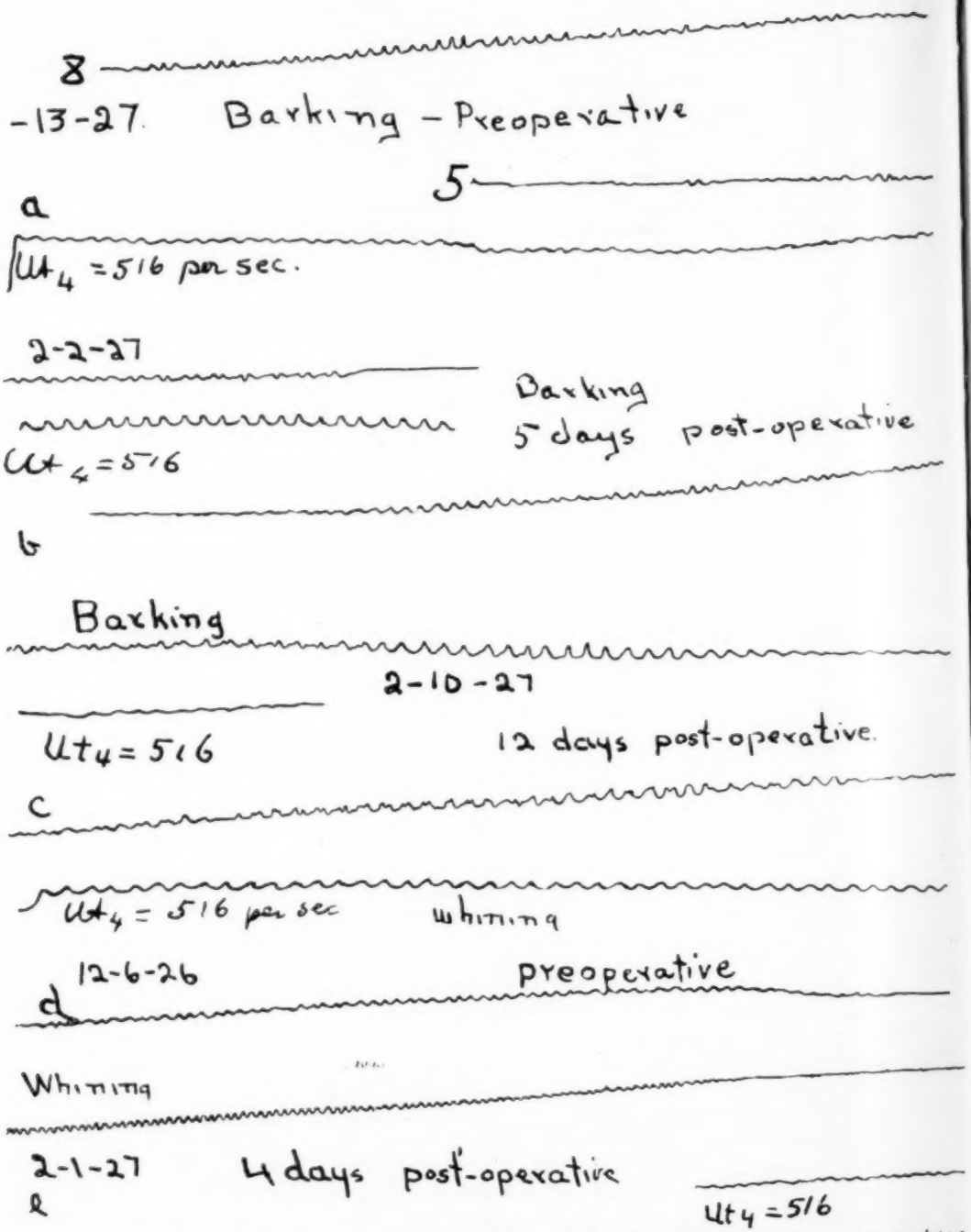


Fig. 6 (dog 7).—Transcriptions of phonograph records of the bark and whine compared to a Ut_4 tuning fork. *a* shows a normal bark before operation; *b*, record five days after operation, showing that the bark is more simple in nature and more like a whine due to weakness; *c*, normal bark twelve days after operation; *d*, normal whine before operation and *e*, record made four days after operation.

dorsal part of the anterior lobe, while the lesion of the second operation passed along the fourth ventricle and into the aqueduct of Sylvius. The second operation severely damaged the lower part of the medulla; it was not possible to say whether there was injury to these parts by the first operation. At a higher level, the nodulus was found intact and did not show secondary degeneration, from which one may infer that the nodulus was not injured at the first operation and that it protected the fourth ventricle from injury. Osmic-acid stained phagocytes and coarse granules of the primary lesion as well as secondary degeneration gave clear evidence of an old injury to the pyramis and the upper part of the uvula. This suggests that the lesion of the first operation was well above the fourth ventricle in the posterior part of the cerebellum as it was in the anterior part.

Comment.—This case appears to be a close counterpart anatomically of that in dog 18, and the physiologic symptoms in the two dogs were also strikingly similar; neither showed unilateral cerebellar symptoms of the body as a whole nor changes in the movements of the vocal cords, but both showed a tendency to fall backward. There were no symptoms after the first operation that were indicative of medullary injury. It is not possible to tell how much of the cortex of the pyramis and the uvula was injured at the first operation, but as normal cerebellar tissue was found mixed with fresh blood it is certain that the first lesion was not as large as the second and was therefore well within the limits indicated by the schematic drawing (fig. 7).

Orally from the middle of the uvula and pyramis, the paths of the lesions could be readily separated and since the dog died too soon after the second operation to permit any physiologic studies, only the lesion of the first operation will be described. As the center of the cerebellum was approached, it became clear that the whole of the base of the nodulus overlying the fourth ventricle was free from both primary and secondary lesions. The lesion passed dorsal to it into the center of the white tracts and between the nuclei fastigii. The lesion was well circumscribed. It completely destroyed the decussation of the fastigii but seemed to encroach on the nuclei themselves slightly, the right a little more than the left. The white tracts that passed to the lobulus centralis were clearly intercepted at its base in the midline. In the same way the lesion passed through the white tracts in the base of the declive and on into the monticulus. Here it passed dorsad, destroying much of the lower half of the monticulus and the adjacent part of the declive. The lesion ended on the anterior surface of the monticulus. The cortex of the lobulus centralis was not involved in the lesion, but the large amount of secondary degeneration seen in the white tracts going to all parts of this lobule indicated a severe injury at its base separating the lobule from its centers. Such secondary degeneration was relatively slight in the lingula.

An additional lesion was seen on the surface of the lower part of the tuber and the upper part of the pyramis. The injury to the tuber was fairly deep. This was the area from which the bone wax was removed. Otherwise, this lesion was the same as that usually found in this position underlying the wound.

Dog 17.—*A young, lactating, fox terrier bitch.*

Operation.—On Jan. 4, 1927, the movements of the vocal cords were observed and recorded by the kymographic and cinematographic methods. The movements were of regular type as seen in the kymographic record, figure 8*a*. The dog was operated on, January 7, an effort being made to injure the lobulus centralis by approaching it through the fourth ventricle. The operation was without complications except that there were respiratory difficulties for about an hour afterward.

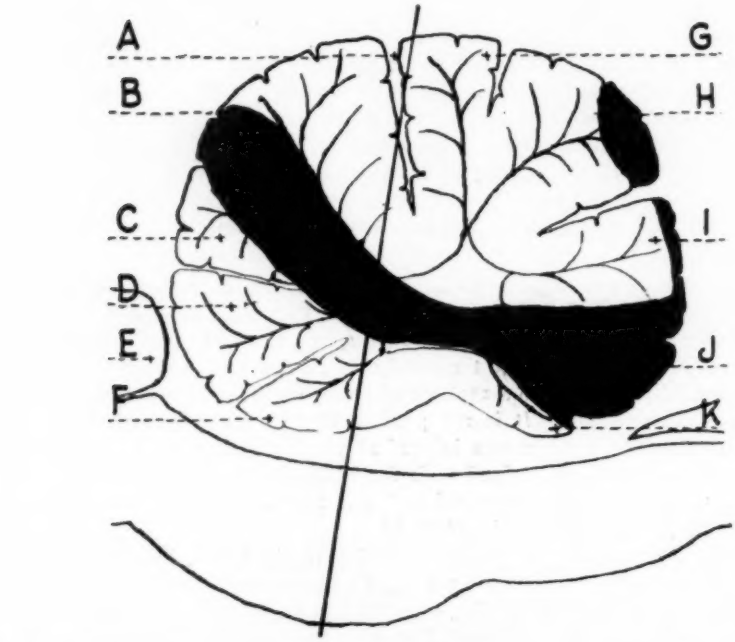


Fig. 7 (dog 7).—Schematic diagram of the cerebellum drawn in the mesial plane to show the extent of the lesion, and a photomicrograph showing the lesion as it passes between the roof nuclei above the lingula.

Results.—Forced movements were not seen. The dog attempted to crawl on the second day and made circus movements in a counterclockwise direction. It would also roll in a counterclockwise direction when lifted from its support. The tone of the right limbs was greater than the tone of the left. The dog showed horizontal nystagmus with the quick component to the right, and an intention tremor of the neck when it attempted to drink. On the third day it was able to walk but was unsteady, owing to an anteroposterior swaying and a tendency to fall to the right. Further whirling, rotating or nystagmus did not occur. The animal's condition improved steadily, but an internal strabismus developed on the tenth day. It would whine to attract attention, but never barked.

Morphine was given, and the vocal cords were observed on the second day after the operation. They were active, with complete abduction and adduction. Numerous accessory movements occurred from time to time, especially when it attempted to howl or whine in response to discomfort. Both kymographic and cinematographic records were taken of these irregularities (figs. 8 and 9). The curves obtained by the cinematographic method do not correspond in form with the kymographic records, but this is due to the fact that there are only ten cinematographic exposures per second and the rate of the accessory movements exceeds this. A definitely abnormal curve was obtained, however. Kymographic records on the eleventh and seventeenth days after operation showed some accessory movements. The rate of the movements of the vocal cords corresponded with the regular respiration, but an irregularity was apparent in their form.

Postmortem Studies.—The dog was killed on the nineteenth day after the operation, and the brain was placed in formaldehyde. Section through the medulla showed a lesion in the floor of the fourth ventricle at the level of the corpus trapezoideum. Sections at various levels through the cerebellum showed a circumscribed lesion extending through the nodulus and lingula.

Microscopic study of the serial sections showed that the main lesion in the cerebellum was relatively small (fig. 10). Caudad, the lesion touched superficially the ventral surface of the uvula and the surface of the nodulus that covers the fourth ventricle. At this level it also just touched the mesial edge of the lowest lobule of the lobulus paramedianus on the left side. None of these parts had been destroyed, except the superficial cortical layer of the lowest lobuli of the nodulus. In the more mesial part of the nodulus there seemed to have been some circulatory disturbance in the white tracts, which were involved in the secondary degeneration. Here dilated blood vessels and some extravasated blood were found, though the mechanical destruction had not penetrated so deeply. Still more mediad, even the nodulus was untouched. The lesion did not encroach on the white tracts of the center of the cerebellum nor on the cerebellar nuclei. At the base of the lobus anterior it invaded the root of the lingula, more extensively on the left than on the right; it involved the upper and medial part of the angle formed by the junction of the fourth ventricle and the cerebellum at its most caudal level just below the nucleus emboliformis. This may include part of the tractus cerebellonuclearis. As it passed through the lingula, the lesion was not extensive. It destroyed little of the cortex, and that part lying in contact with the medulla was intact. A lesion about 1 mm. in diameter passed in a caudal-oral direction through the center of the lingula, emerging at the ventral and upper surface and just touching the most ventral and lowest tip of the lobulus centralis; but there was only a slight superficial reaction in a limited area. The lesion then passed into the aqueduct of Sylvius, involving the substantia grisea centralis of both left colliculi and producing a small lesion on the mesial surface of the anterior corpora quadrigemina.

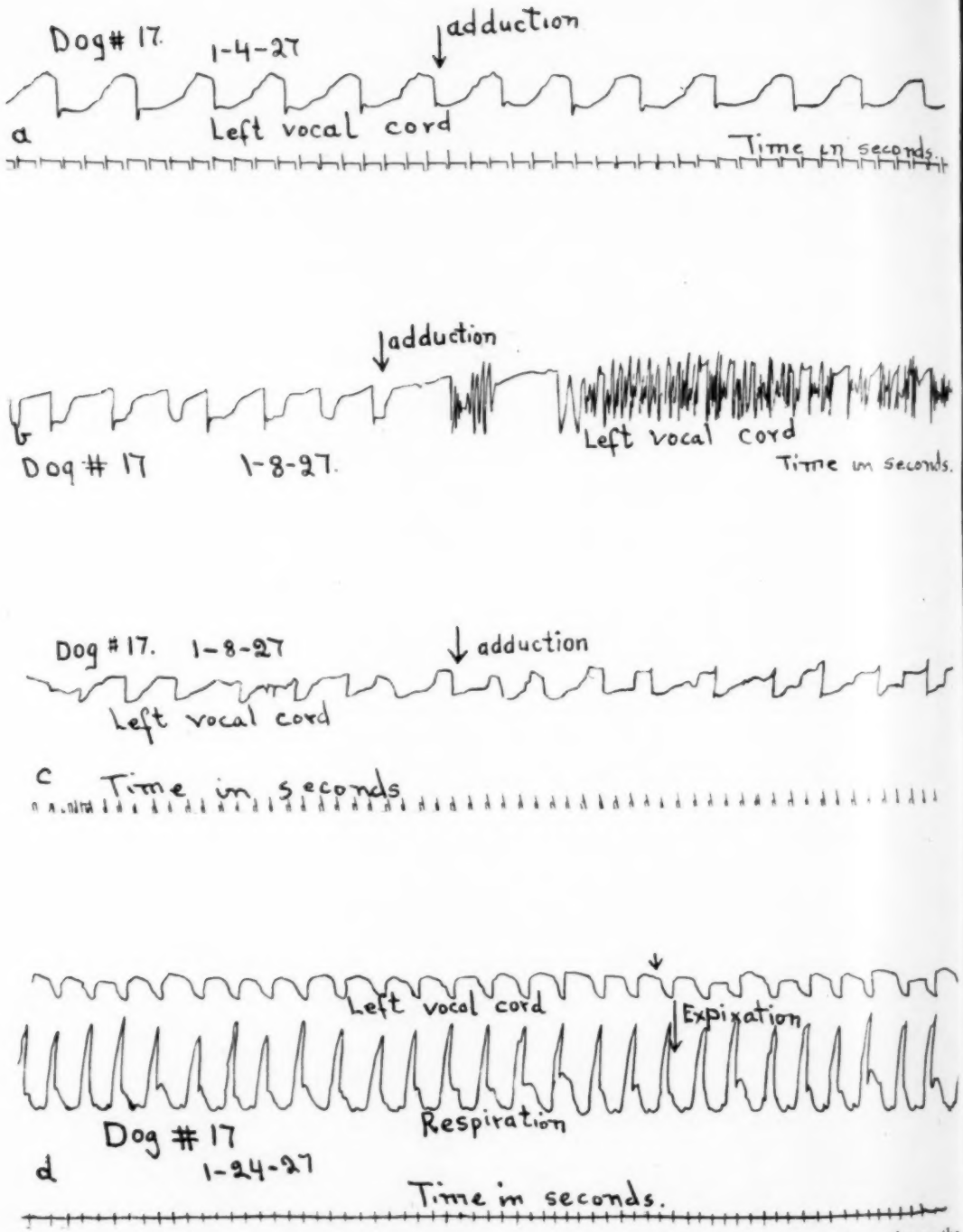


Fig. 8 (dog 17).—Kymographic records of the movements of the left vocal cord. *a* shows the record before the operation; *b*, record twenty-four hours after the operation, showing numerous accessory movements which have been initiated by whining; *c*, accessory movements without whining; *d*, irregularities seventeen days after operation.

The lesion in the medulla began in the closed part and passed onto the floor of the fourth ventricle in the midline, as far forward as the beginning of the root of the eighth nerve. For the most part the lesion was superficial, with some underlying congestion. It tended to be a little more severe on the left side than on the right. It threatened the nucleus of the twelfth nerve, the nucleus dorsalis vagi, the nucleus dorsalis of the eighth and the fasciculus solitarius and the fasciculus longitudinalis posterior. It seemed to involve these only superficially.

Dog 22.—*A young, fox terrier bitch.*

History.—On Jan. 14, 1927, the movements of the vocal cords were studied and recorded. They were entirely normal (fig. 11*a*). When occasional irregularities are seen in the movements of the vocal cords, it will be noted that they also occur in the respiratory curve and are therefore due to respiratory irregularities or bodily movements.

Operation and Results.—On January 19, the dog was operated on. Following the operation, a vertical nystagmus with the quick component downward was noted. On the next day forced movements did not occur, but there was a slight tendency to rotate in a clockwise direction and to fall to the left. The legs were weak. The fore legs were held in extended and awkward positions, but they were not hypertonic. The hind legs appeared weakest, as the animal would support itself on the fore legs but would not rise on the hind legs. It vomited all food

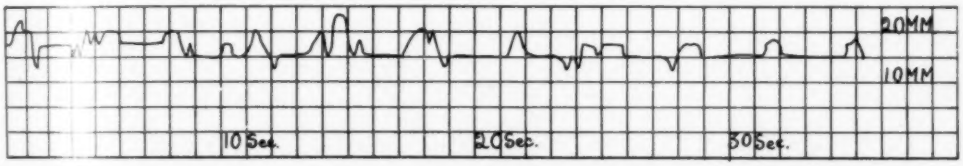
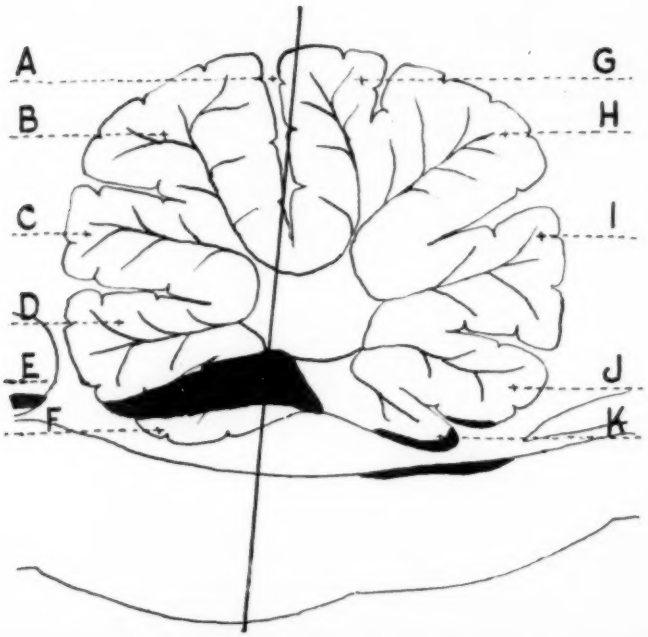


Fig. 9 (dog 17).—Graph of movements of the vocal cords obtained by the cinematographic method twenty-four hours after operation. This graph does not compare exactly with *b* or *c* in figure 8, but this is due to the fact that the cinematographic film exposures occur only at a rate of ten per second and the accessory movements have a higher rate. However, it does show definite irregularities.

and water taken. Its condition remained stationary, except that after the second day nystagmus or the tendency to rotate or fall to the left was not present. The vomiting persisted and the dog died on the eighth day, while under morphine anesthesia, of hemorrhagic enteritis and inanition. The condition was probably due to distemper, as this was epidemic in the kennels at the time. The animal never barked after the operation.

The movements of the vocal cords were examined while the animal was under morphine anesthesia on January 21, forty-eight hours after the operation. The movements appeared extensive and steady, and corresponded with the regular respiration except for an occasional quick accessory movement either in one or in both cords. The strength of the jaw was good, and the tongue was in a normal position. However, there appeared to be a certain narrowing of the back of the mouth as though the soft tissues were collapsing. The hyoid bone consequently stood out in clear relief. This was usually seen in the dogs after operation. The kymographic records (fig. 11*b*) showed that the movements of the vocal cords were extensive and regular, but the records vary from the normal in two respects: The accessory movements seen on direct observation are clearly shown and are



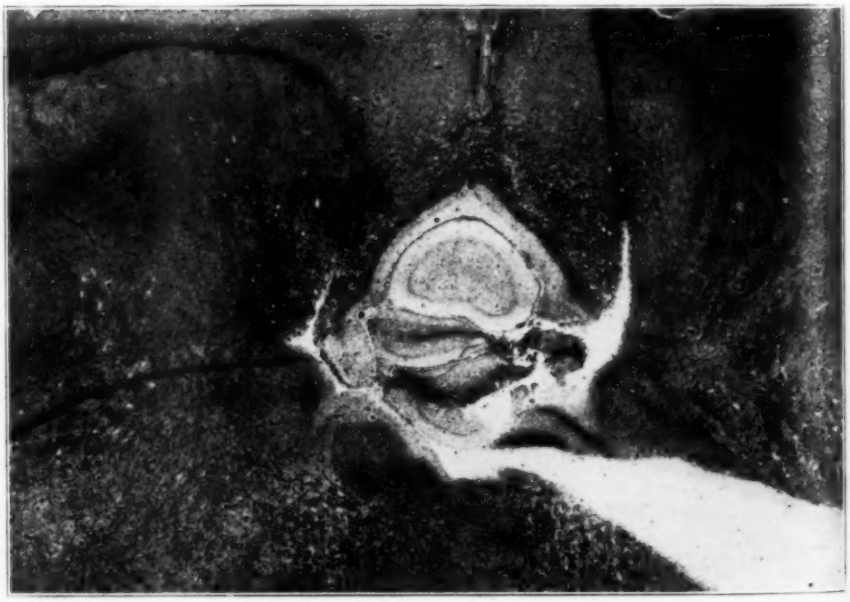


Fig. 10 (dog 17).—Schematic diagram of the cerebellum drawn in the mesial plane showing the extent of the lesion, and a photomicrograph of a frontal section showing the lesion in the lingula.

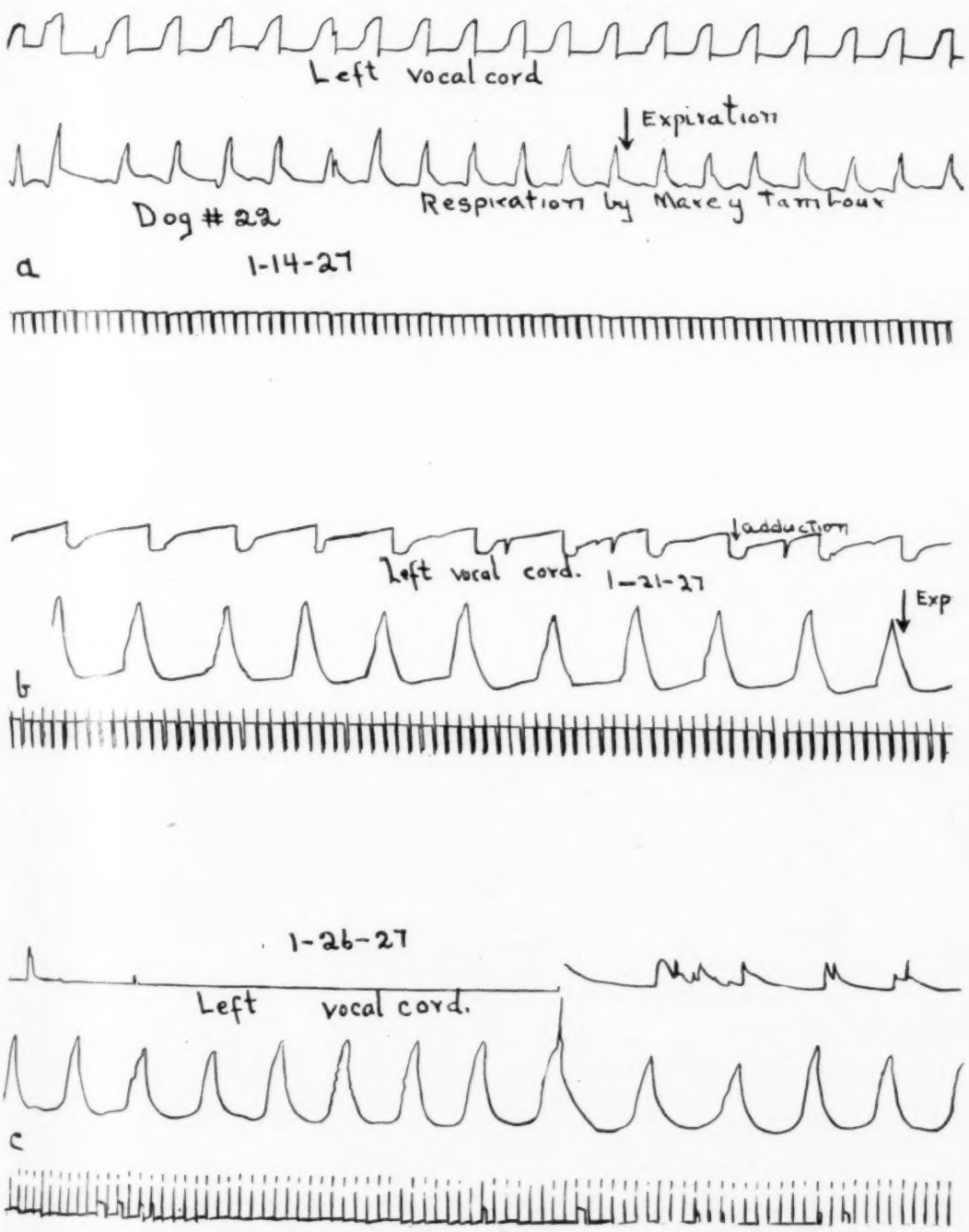


Fig. 11 (dog 22).—Kymographic records of the movements of the vocal cords. *a* is the record before operation, showing a few accessory-like movements which, however, are reflected from the respiration; *b*, record forty-eight hours after the operation, showing the true accessory movements; *c*, seven days after operation, showing the accessory movements alone as the vocal cords are not moving with respiration owing to the depth of the anesthesia.

entirely intrinsic in the vocal cords as they are not present in the respiratory curve. These accessory movements are one of the prominent features in the disturbance in movements of the vocal cords obtained in these experiments. It will be noted that many normal movements of the vocal cords may occur without any accessory movements. Furthermore, it will be seen that while before operation the vocal cords remained in adduction longer than in abduction, after operation this relationship is reversed.

On January 27, though the dog was weak from constant vomiting and inanition, morphine was again given in an effort to repeat the examination. The kymographic records were obtained when the dog was so deeply under morphine that the movements of the vocal cords which normally accompany respiration (fig. 11*c*) had ceased though respiration was good, and the accessory movements are therefore recorded by themselves. The dog died during the night.

Postmortem Studies.—The next morning, the entire brain was placed in formaldehyde. Intracranial hemorrhage, meningitis or other evidence of increased intracranial pressure were not present nor were any external lesions found. Frontal sections of the cerebellum showed a thin layer of old blood at the base of the cerebellum, but there was none on the floor of the fourth ventricle. There was a clear lesion of the nodulus, at the level of the corpus trapezoideum, which extended to the lingula and the lobulus centralis. Serial sections were stained alternately with the Weigert-Pal and the hemotoxylin-van Gieson stains, as the dog had not lived long enough to insure useful Marchi preparations.

Microscopic studies did not show meningitis or other form of infection. The cerebellar nuclei were unhurt. The chief lesion was in the lobulus centralis (fig. 12), passing through the lingula and barely touching the first of the branch lobuli of the declive. The cerebellar cortex was destroyed in this area, and extravascular blood was present. The injury was in the midpart of the lobulus centralis and did not touch the most anterior or either lateral surface of the cortex. These parts, which surrounded the lesion, showed the normal architectural structure of the zona molecularis, Purkinje cells and zona granulosa. However, as the lesion passed through the base of this lobule, it invaded the adjacent white tracts that pass from the cerebellar nuclei to the medulla and include the tractus cerebellonuclearis.

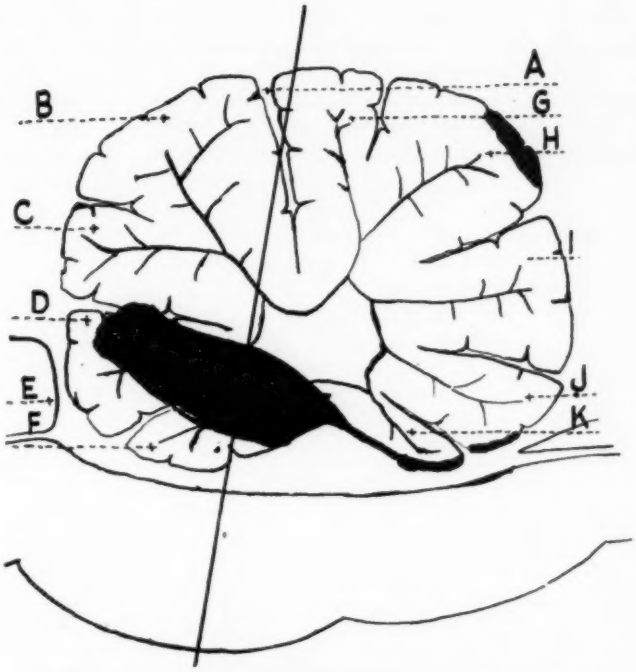
There was a superficial lesion in the uvula and nodulus, associated with a thin layer of blood. This was caused by the elevation of these parts with the spatula during the operation. One ventral lobulus of the lobulus paramedianus showed also a slight injury of the same type. A slightly deeper lesion, which may have been of the same origin, was found in the most inferior part of the nodulus.

The blood at the base of the cerebellum lay within the cerebellar pia; blood was not found on the floor of the fourth ventricle. At one point over the acoustic area, however, it lay so close that it had produced a slight, superficial cellular reaction. The striae acousticae of one side were also damaged by a small lesion. This lesion was followed orally into the lateral wall of the fourth ventricle, where it formed the lesion in the cerebellar white tracts and the base of the lingula already mentioned.

Dog 25.—*A young, male terrier.*

History.—On January 20, phonograph records were taken of the dog's whine or howl while it was under morphine anesthesia, and kymographic and cinematographic records were taken of the normal movements of the vocal cords.

Operation and Results.—The animal was operated on, January 21, without complications. Immediately afterward, it howled normally. It had forced move-



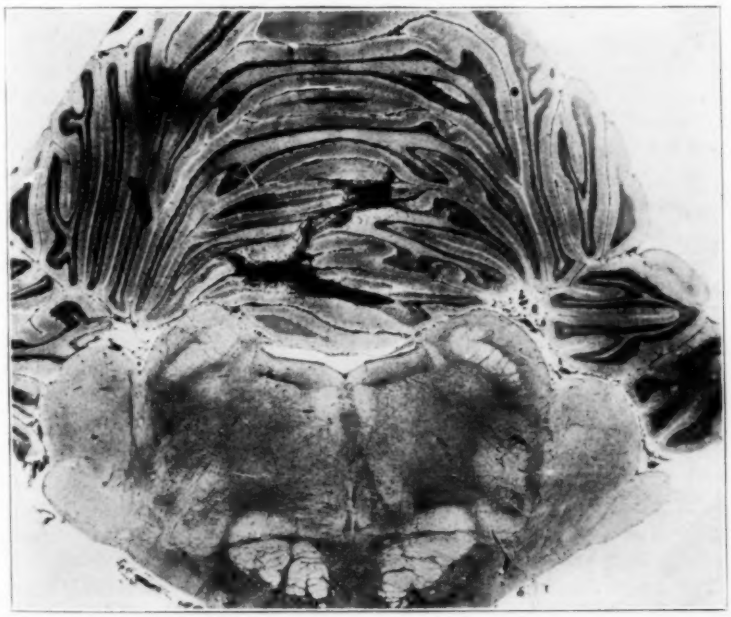


Fig. 12 (dog 22).—Schematic diagram of the cerebellum drawn in the mesial plane showing the extent of the lesion, and a photomicrograph of a frontal section showing the lesion in the lobulus centralis and lingula.

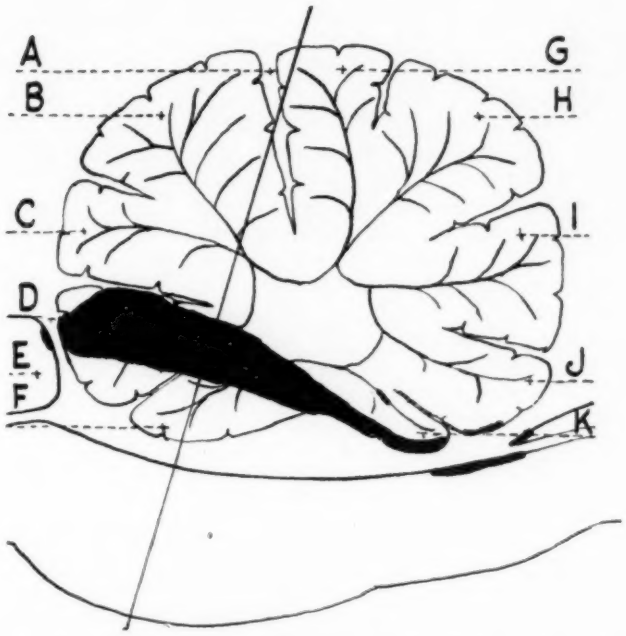
ments of the rolling type in a counterclockwise direction which necessitated tying its legs; as a result, the right hind leg was broken. On the second day, the dog was quiet and cheerful. The right eye turned down and in, the left up and out. An oscillation of the head and neck was present. When lifted from its support, the dog tended to roll in a counterclockwise direction. On account of the condition of the leg, the dog never attempted to walk much. On the third day, while the dog was under morphine anesthesia, kymographic records of the movements of the vocal cords were made. Because of the broken leg and an injured nose, the dog did not remain quiet; the twitchings of the body were recorded in both the respiratory curve and the vocal cord curve. Irregularities and accessory movements could be seen directly in the movements of the vocal cords. Abnormal cinematographic records were obtained. On the sixth day, the dog was quiet while kymographic records were made which revealed the accessory movements. On the same day, phonographic records were taken of the howl while the dog was under the influence of morphine; transcriptions of these phonographic records did not show any difference in the howl as a result of the operation. The dog was found dead of pneumonia on the eleventh day.

Postmortem Studies.—The brain was fixed as usual in formaldehyde. After fixation it was cut and examined. Meningitis was not present. Frontal sections through the cerebellum showed a clear circumscribed lesion in the lobulus centralis, lingula and nodulus.

Microscopic study of serial sections showed the main lesion to run in the midline along the lower part of the nodulus across the base of the lingula and into the lobulus centralis, and then for a short distance into the posterior corpora quadrigemina (fig. 13). The most severe lesion was in the lobulus centralis. Beginning caudad, the lesion involved superficially the lower surface of a part of the uvula and, to a negligible degree, the mesial edge of one lobule of the lobulus paramedianus on the left side. Passing mediad, it involved the lower surface of the nodulus somewhat more severely, the exposed cortical layer overlying the fourth ventrical being destroyed in some places. At this level, blood was found in the fourth ventricle. It overlay the closed portion of the medulla and produced a slight circulatory disturbance in the fasciculi of Goll. More orally, it overlay the nuclei of the twelfth, tenth, ninth and eighth nerves, for a short distance producing some circulatory changes in these parts. There was slight disturbance of a small area of the tissue superficial to the right nucleus of the eighth nerve at one point, and at the same level there was a slight cellular reaction in the left corpus restiforme.

Passing mesiad in the cerebellum, the lesion continued along the lower surface of the nodulus to the base of the lingula and here passed more deeply, injuring the central white tracts as they passed from the cerebellar nuclei along the mesial surface of the peduncle on the right side. This probably included the tractus cerebellonuclearis. The lesion then cut across the base of the lingula in the midline so that most of the lateral parts of the cortex were still in connection with the centers; there was little actual destruction to the cortex of this lobulus. In the lobulus centralis the lesion involved more of the cortex of the upper part, but there was a severe lesion of most of the tracts of the lower parts as well. There was also a superficial injury to the declive just above the lobulus centralis. The lesion then passed into the aqueduct of Sylvius and slightly injured the substantia grisea centralis at the level of the decussation of the posterior corpora quadrigemina.

Dog 10.—*A male silk spitz, with puppy or first canine teeth, very noisy and active.*



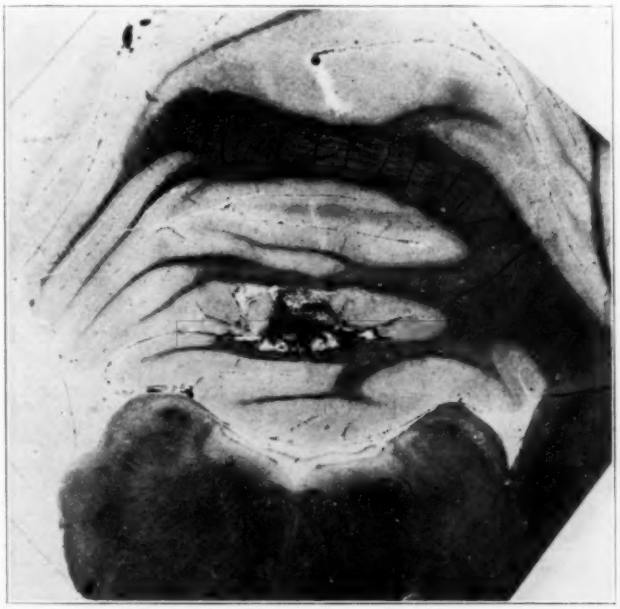


Fig. 13 (dog 25).—Schematic drawing of the cerebellum in the mesial plane to show the extent of the lesion, and a photomicrograph of a frontal section showing the lesion in the lobulus centralis and lingula.

History.—The movements of the vocal cords were observed while the dog was under the influence of morphine, Dec. 5, 1926, and were found entirely normal.

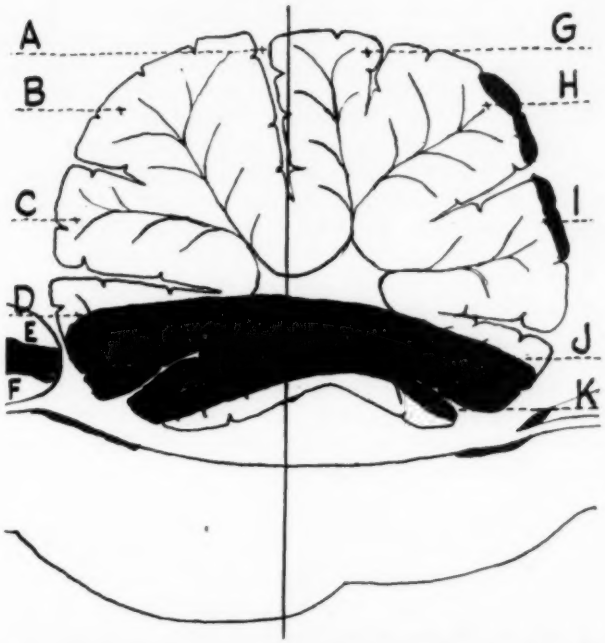
Operation and Results.—The dog was operated on, December 7, the lobulus centralis being aimed at through the fourth ventricle. Afterward, the eyes showed the usual skew deviation. Vertical nystagmus, with the quick component downward, also was present. Forced movements did not occur. On the next day, the dog attempted to walk but rotated in a clockwise direction and fell to the left. The tonus was greater on the left side of the body then on the right. There was marked oscillation of the head and neck in the form of an intention tremor. Distemper developed on the third day, and the dog was ill for a week; it recovered, so that on the seventeenth day after operation it was running about freely but in a clockwise direction. At this time it was observed to fall over backward occasionally. It barked loudly, rapidly and normally. It was killed on the twenty-fourth day.

When the movements of the vocal cords were observed, the following phenomena were described: "There are markedly unusual movements, especially in abduction. The swing back and forth was so pronounced as to make uncertain whether the vocal cords were attempting to adduct or abduct until the movement was completed, when adduction occurred with the usual speed and with one single steady sweep. Such activities lasted during a few respirations and then abduction as well as adduction were normal." This is clearly the same sort of phenomena as is seen in the kymographic records of dog 17 (fig. 8). At the same time it was noted that the back of the mouth and the throat converged, the hyoid bone stood up clearly, and the soft tissues seemed lax. Nothing abnormal was detected in the muscles of the tongue and jaw.

On the seventeenth day, after recovery from the distemper, kymographic records showed that the movement of the vocal cords were normal. Accessory movements were not observed at this time.

Postmortem Studies.—The brain was fixed in toto in formaldehyde. Frontal sections through the cerebellum and medulla oblongata showed a lesion in the uvula, nodula, lingula and possibly in the lobulus centralis. There was also a lesion in the overlying white tracts at the level of the decussation of the nuclei tecti. Possibly the nuclei themselves were hurt. Sections in the midbrain showed a lesion in the posterior corpora quadrigemina.

Microscopic study of serial sections showed a lesion transversely through the whole length of the cerebellum (fig. 14). Caudad, it involved a destruction of the cortex in the midline of all of the ventral surface of the uvula, the lower part of the pyramis and the upper part of the nodulus. Parts of the nodulus, although injured, were still present separating the floor of the fourth ventricle from the lesion in the uvula and pyramis. The mesial and dorsal surfaces of both lobuli paramediani were also involved, the right showing destruction of the mesial half of the two ventral lobules and the left showing a superficial reaction of the mesial edge of the ventral lobulus. The lesion passed mesiad and destroyed the white tracts to the inferior vermis, including those which connect the lobuli paramediani with the pyramis. Only the upper part of the pyramis remained intact. More mesiad, the lesion passed between the two nuclei tecti and severed the decussation from these nuclei. The lesion tended to surround each of these nuclei, involving the mesial, the ventral and also the two lateral borders. At the level of the lingula the right nucleus tectus itself was involved in the lesion, which passed from the lower border to the center of the nucleus. The other cerebellar nuclei were not injured, although there was also a lesion of the mesial surface of the peduncle just ventral to the nucleus globosus and the nucleus



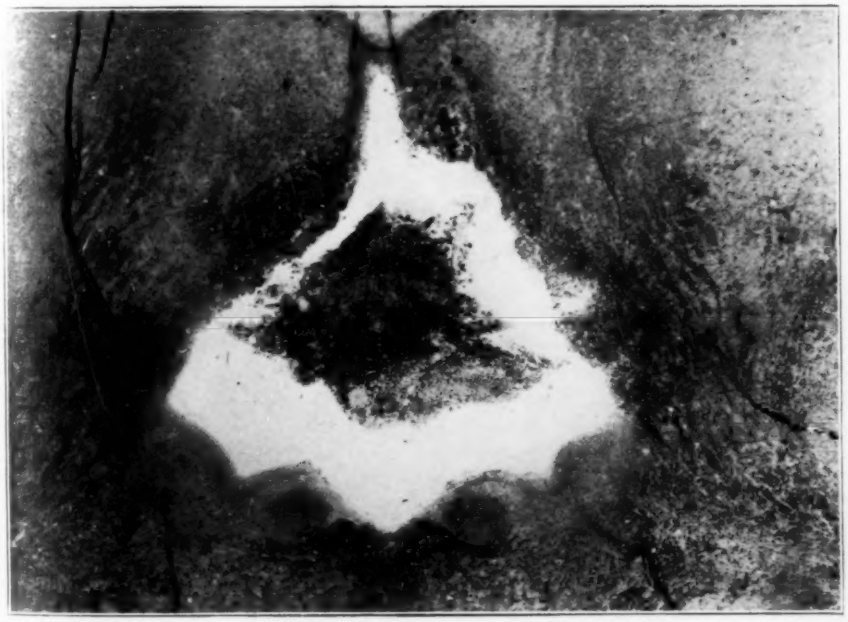


Fig. 14 (dog 10).—Schematic drawing of the cerebellum showing the extent of the lesion, and a photomicrograph of a frontal section showing the lesion at the base of the lingula and in the *IAK*.

dentatus on the right side which probably involved the tractus cerebellonuclearis. The lingula at this level was separated from the white tracts and adjacent cortex through the middle of the lobulus centralis and lingula leaving, however, the lateral part of these lobuli intact. The lesion was about 3 or 4 mm. in diameter and lay to the left of the midline, overlying the left brachium conjunctivum. There was marked secondary degeneration in both brachia conjunctiva, but a primary lesion was not found here. The lesion passed out of the ventral surface of the lobulus centralis and lingula and into the aqueduct of Sylvius at the level of the decussation of the posterior quadrigeminate bodies; it made a small lesion on the right side in the central gray stratum which tended to become more mesial as it passed forward and entered the posterior corpus quadrigeminum only at the most oral and mesial part; however, it involved a considerable extent of the anterior corpus quadrigeminum, after which it ended on the mesial and upper surface of this body.

Several accidental lesions were also present. In the cortex of the tuber was the usual lesion resulting from the overlying wound. It involved the superficial layer, with little actual destruction. In the right sulcus paramedianus it passed to the second and third lobuli but did not involve the lobulus paramedianus. A small lesion was present in the right fasciculus of Burdach, but it did not involve the nucleus. This area was also covered with the old blood clot that was seen in the fourth ventricle. This blood was lying only on the closed part of the medulla, and nowhere was free blood lying on the floor of the fourth ventricle. There was an injury to the medulla on the right side, at the level of the twelfth nerve, which involved the right corpus restiforme and was about 1 mm. deep. A similar lesion was seen, at a little higher level, that involved the nucleus dorsalis of the eighth nerve on the left side. There was a slight injury to the floor of the fourth ventricle in the midline, from the beginning of the pons to the beginning of the aqueduct of Sylvius. This was superficial and did not seem to involve any tracts or nuclei.

Dog. 14.—*A young, tan shepherd.*

History.—On Dec. 18, 1926, the movements of the vocal cords were noted to be normal, and the kymographic records in figure 15*a* were made. Observations were repeated on December 21, and cinematographic films were taken, which also showed normal movements.

Operation and Results.—On December 22, an operation was performed that aimed at the lobulus centralis through the fourth ventricle. A considerable amount of hemorrhage was encountered during the operation. Within ten minutes after being taken from the operating table, the dog was rolling rapidly and continuously in a counterclockwise direction. A skew deviation of the eyes and vertical nystagmus with the quick component downward were present. After the first day, forced movements were not noted unless the dog was lifted from its support, when it would tend to roll in a counterclockwise direction. If encouraged to move, it would make circus movements or would rotate on the floor in a counterclockwise direction. It lay on the right side with the head twisted far back to the left and the nose pointed down its back. Any effort to straighten the neck met with marked resistance. After the fifth day, however, the dog lay on the left side with the head flexed on the chest; circus movements changed to a clockwise direction, while rolling was still counterclockwise. The muscles of the neck were stiff, the right posterior group and the left anterior group standing out in continuous spasm. Mixed symptoms were still noted on the ninth day but were interpreted as follows: "It may be that attitude and rotating or circus movements, which is never forced, are voluntary compensations

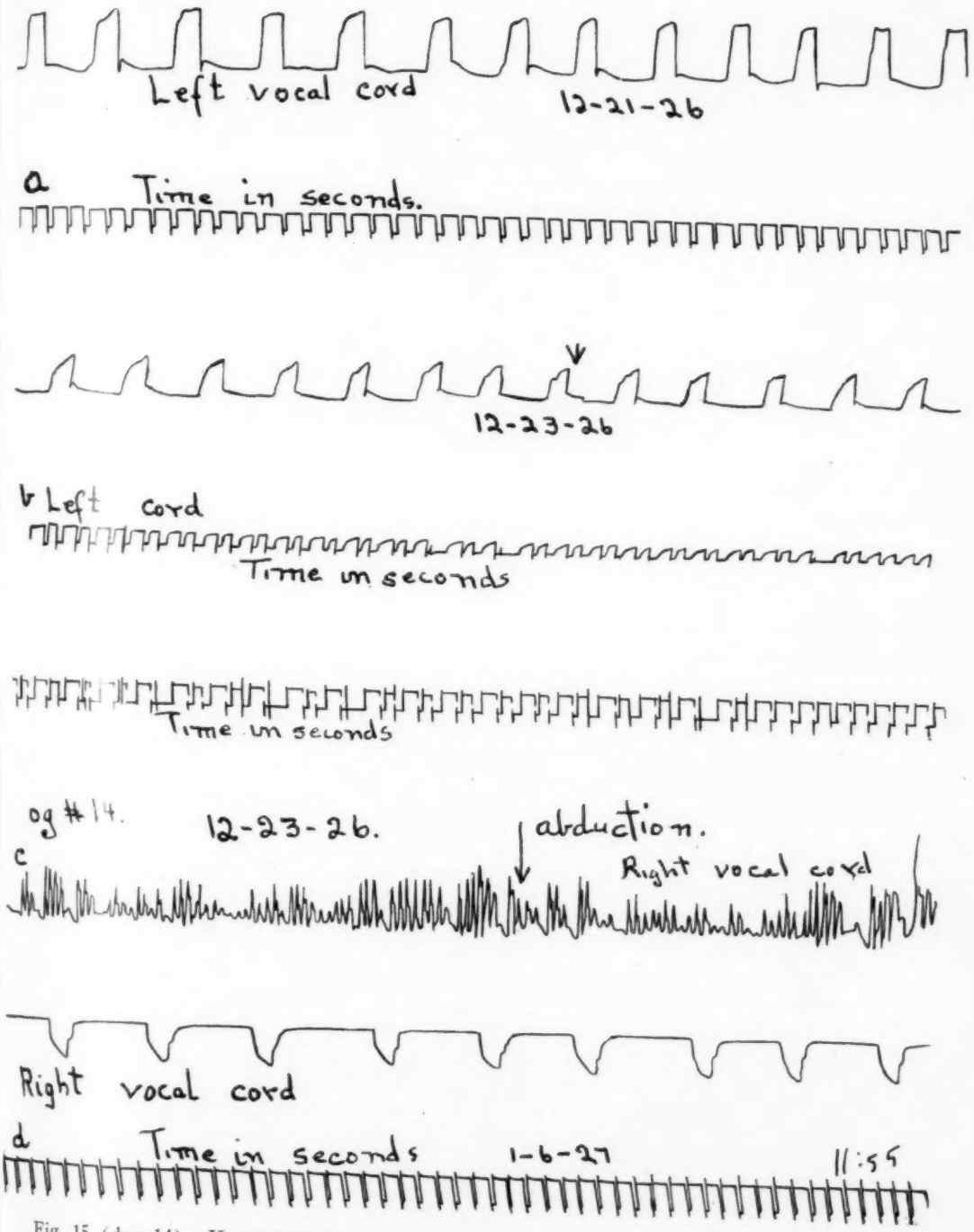


Fig. 15 (dog 14).—Kymographic records of the movements of the vocal cords showing; *a*, normal movements of the left vocal cord before operation; *b*, twenty-four hours after operation; *c*, accessory movements of the right vocal cord twenty-four hours after operation, and *d*, normal movements of the right vocal cord fifteen days after operation.

for the forced counterclockwise rolling." The dog became weaker, acquired distemper and died on the sixteenth day.

The movements of the vocal cords were examined under morphine on the second day, and a peculiar phenomenon was noted. The two vocal cords were not working in unison. The movements of the left cord appeared normal; steady full movements occurred with each respiration. The right vocal cord, however, showed a greater excursion, with numerous rapid movements. This difference, as recorded on the kymograph, is shown in figure 15*b* and *c*. The same phenomenon was seen in the two nostrils; the left expanded and contracted normally with each respiration, while the right showed the same sort of exaggerated and rapid movements seen in the vocal cords. The lower jaw was pulled further to the left than the upper jaw, but at this time the head was twisted with the nose toward the left shoulder.

On the fifteenth day after operation, all the abnormal reactions in both vocal cords and nostrils had disappeared. The movements of the vocal cords were in unison, and were steady and regular, as shown in figure 15*d*.

Postmortem Studies.—The brain was fixed in formaldehyde. Signs of meningitis or gross blood were not found in the cranial cavity. After fixation, the brain was cut and examined. On frontal section through the forebrain, a lesion was found in the most dorsal part of the right cornu ammonis. Blood was not found in the lateral ventricle, and hydrocephalus was not present. This injury extended forward from a small lesion in the right posterior corpus quadrigeminum and the aqueduct of Sylvius. Sections through the cerebellum showed lesions in what were apparently the lingula and nodulus, and there was old blood in the fourth ventricle.

Study of the serial sections showed that the main lesion was extensive, taking a transverse course through the roof of the fourth ventricle and midbrain (fig. 16). In the cerebellum, it started caudad with the ventral surface of the nodulus and uvula. Nearly the whole of the nodulus was destroyed; only a small mesial portion on the right remained, and this showed conspicuous degenerative changes. The lower half of the uvula also was entirely destroyed; the upper half was intact but showed many changes which were also seen in the surface of the pyramis and tuber and were doubtless due, as usual, to the presence of the overlying wound. Those parts of the lobuli paramediani adjacent to the main lesion were also injured. On the right injury was slight, so that the lowest lobulus showed reaction only without destruction, but on the left several lobuli showed destructive and degenerative changes on their mesial surfaces.

As the lesion passed mesiad, it involved the center of the cerebellum on the left side so that the mesial surface of the white area showed destructive and hemorrhagic changes, and there was a small, well circumscribed lesion in the caudal part of the left dentate nucleus. More orad, a more severe lesion was found cutting directly through the whole length of the right nucleus fastigii and extending laterad into the oral end of the right nucleus globosus. A lesion also was present between the nuclei tecti. Some injury had occurred to the right side of the lingula, and the rest of the lingula was pushed to the left by the presence of blood clot. The lesion interrupted the white tracts to the lobulus centralis in the midline and produced a relatively slight injury to the cortex of this lobulus. At this point the lesion overlaying the right brachium conjunctivum and produced a superficial change in it, but both brachia were much more severely involved by the secondary degenerative process. The lesion passed out of the right ventral surface of the lobulus centralis and lingula into the central gray stratum of the aqueduct of Sylvius and the right posterior corpus quadrigeminum. The tissues orad to this were not sectioned.

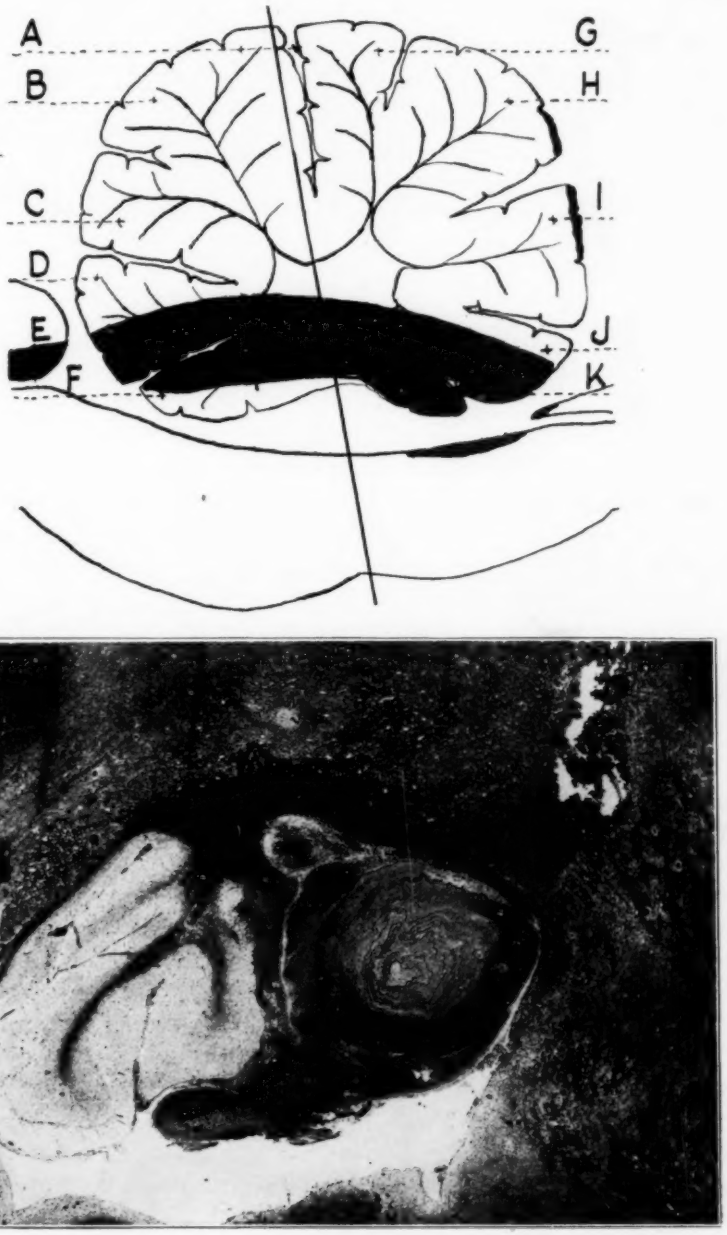


Fig. 16 (dog 14).—Schematic drawing of the cerebellum in the mesial plane to show the extent of the lesion, and a photomicrograph of a frontal section to show the lesion about the base of the lingula.

The presence of the blood clot in the fourth ventricle was associated with several lesions in the medulla. Beginning at a level just below the opening of the medulla, there was a superficial reaction on the right side beneath the blood clot. This did not seem to disturb any tracts or nuclei. As the medulla opened up into the fourth ventricle, this reaction was seen on the right side of the floor in all the area which was in direct contact with the blood. Both right and left nuclei vestibuli were injured by a deep lesion. The lesion in the lingula and cerebelar nuclei passed laterad on the right side and injured the mesial surface of the peduncle at the angle made by the floor and the roof of the fourth ventricle, probably involving the tractus cerebellonuclearis.

The mesencephalic root of the nucleus of the fifth nerve showed secondary degeneration of severe grade. This possibly accounts for the unilateral symptoms in this animal. Johnston[12] has already suggested that this nucleus serves a sensory function, and Allen[13] has said that this sensory function is related to the muscles of mastication.

COMMENT AND CONCLUSIONS

The series of animals readily divides itself into two groups: those which did not show changes in the activities of the vocal cords as a result of operations on the cerebellum, and those which showed specific motor disturbances in the function of the vocal cords following such operations. Four of the animals belong in the first group and five in the second. In all the latter, an effort had been made to injure the lobulus centralis through the fourth ventricle.

The functional disturbances in the movements of the vocal cords could be seen on direct observation and were recorded by kymographic and cinematographic methods. Two forms of disturbances were noted: general irregularity of the usual movements associated with the respiratory rhythm and accessory movements independent of the respiratory rhythm. Both of these are typical cerebellar ataxic disturbances. The accessory movements were most pronounced during the first few days after the operation and then, as the other cerebellar symptoms improved, these movements disappeared so that by the time the dogs were killed on the eighteenth day none could be elicited. The accessory movements were not always present. In fact, while the dog was under observation there would be long periods in which none could be seen. If the dog was disturbed, however, so that it attempted to howl or whine, these accessory movements would immediately appear (fig. 8 *b*). They may be compared with the action tremor which was noted also in the dog's neck and head when it attempted to take food or water from a pan, and thus are analogous to the so-called intention tremor. Similarly, in disturbances in human speech of cerebellar origin, the

12. Johnston, J. B.: The Radix Mesencephalica Trigemini, J. Comp. Neurol. **19**:593, 1909.

13. Allen, W. F.: Application of the Marchi Method to the Study of the Radix Mesencephalica Trigemini in the Guinea-Pig, J. Comp. Neurol. **30**:169, 1909.

difficulties are said to increase with the patient's effort. Also it will be noted that the accessory movements are usually associated with abduction (figs. 8 and 11).

Since the movements of the vocal cords may be looked on as a form of alternate motion, disturbances in them may be said to be a form of adiadokokinesis. This has also been pointed out by Bonhoeffer.[14] Indeed, if the curves obtained in this work are compared with those obtained by Holmes [15] in his analyses of motor disturbances in injuries to the cerebellum received during the war, they will be seen to be similar. The irregularities seen in *b* and *c* of figure 8 compare well with the curve of the adiadokokinesis shown by Holmes in supination and pronation of the arm. It will be noted also that the record of accessory movements in figure 8*b* compared well with the curve of the knee reflex in a patient with cerebellar injury. Holmes spoke of "adventitious" and "pendular" movements, whereas the terms "accessory movements" and "irregularities" are used here. As he said that the disorders in phonation and articulation observed in his patients were due to the same muscular disturbances that were found elsewhere, one would expect a similarity in the curves.

The experiments reported do not indicate any specific disturbances of the phonetic function of the dog. It is true that the dogs did not bark for some time after operation, but they were sick and a sick dog does not bark. They were depressed and apprehensive and usually refused food for several days. In addition, it must be remembered that the attitude and gait were disturbed; usually, a dog will brace itself on its limbs before it barks. Other workers have recorded the absence of the bark for one and a half months.

Of my nine dogs, five barked before death on the eighteenth day; three died of conditions following the operation and were never well enough to bark; only one (dog 17) did not bark before the eighteenth day, when it might have been expected to do so. All the dogs howled and whined immediately after the operation. The phonetic studies of the whines of dog 25 and dog 7, in both of which there were severe lesions in the anterior lobe of the cerebellum, do not show variations. Nothing abnormal was detected in the sound of the dogs' barks following the operations. The phonetic study of the bark in dog 7 did not show marked changes. Although the barking seemed to require great effort on the fifth day after operation, when it first occurred and the transcribed record was simpler than the one obtained

14. Bonhoeffer: Ueber den Einfluss des Zerebellum auf die Sprache, Monatschr. f. Psychiat. u. Neurol. **24**:379, 1908.

15. Holmes, Gordon: Brain **40**:461, 1917; Croonian Lectures, Lancet **202**: 1177, 1922.

before the operation, both of these facts can be accounted for by the dog's general weakness, especially as study of the movements of the vocal cords did not show abnormalities. However, it should be emphasized that the absence of disturbance in barking or howling cannot be accepted as a fair criterion of disturbance in function of the vocal cords of the nature which might be here anticipated, for these activities are relatively simple and the disturbances which are reported in human speech are much more complex. It may be true, however, since vocalization is simpler in the dog and since volitional vocalization is not readily studied, that lesions in the cortex of the cerebellum which do not produce demonstrable change in the phonetic activities of dogs might yet result in definite changes in phonation and particularly in articulation in the speech of man.

Studies of the primary lesions in the cerebellums of these dogs show a distinct difference in the distribution of the lesions in the two groups, which correlate well with the observations that one group did not show functional disturbances while the other showed a definite cerebellar ataxia of the movements of the vocal cords. Composite pictures are given in figure 17.

Figure 17 *1* is a composite diagram constructed by superimposing in one diagram all lesions in the four dogs (23, 11, 18 and 7) that did not show any physiologic changes in the vocal organs. This diagram shows a wide range of primary lesions throughout the vermis, and the microscopic study of the sections showed that all those parts of the anterior lobe not involved in primary lesions were involved in the secondary degeneration, in one case or another. Furthermore, it will be observed that the white tracts between the nuclear systems were cut. The significant thing, however, is that those tissues which surround the fourth ventricle were not disturbed in any of these brains. It may be said, therefore, that lesions of all parts of the vermis, of the white tracts through the middle of the cerebellum and of the roof nuclei failed to produce changes in the movements of the vocal cord that were demonstrable by the methods used.

Of the five dogs (17, 25, 22, 10 and 14) that had shown definite physiologic changes in the movements of the vocal cords, all had lesions which involved the tissues about the fourth ventricle. In figure 17, *2* is a composite diagram for this group. These lesions varied in extent and position, involving such parts as the fasciculi of Goll and Burdach, the tissues superficial to the nuclei of the eighth, ninth, dorsal tenth, and twelfth nerves, and sometimes the nucleus of the eighth nerve itself, the mesial surface of the peduncles and the corpora quadrigemina. The lesions were usually not severe, and none of these areas was injured in all five dogs. Dog 22 did not show any lesions in the corpora quadrigemina, and dogs 22 and 25

showed only small, superficial lesions in the most inferior part of the floor of the fourth ventricle. However, the importance of these lesions must not be overlooked

From figure 17 *2*, it would appear as if the lobulus centralis had been more severely injured in the animals that showed changes in

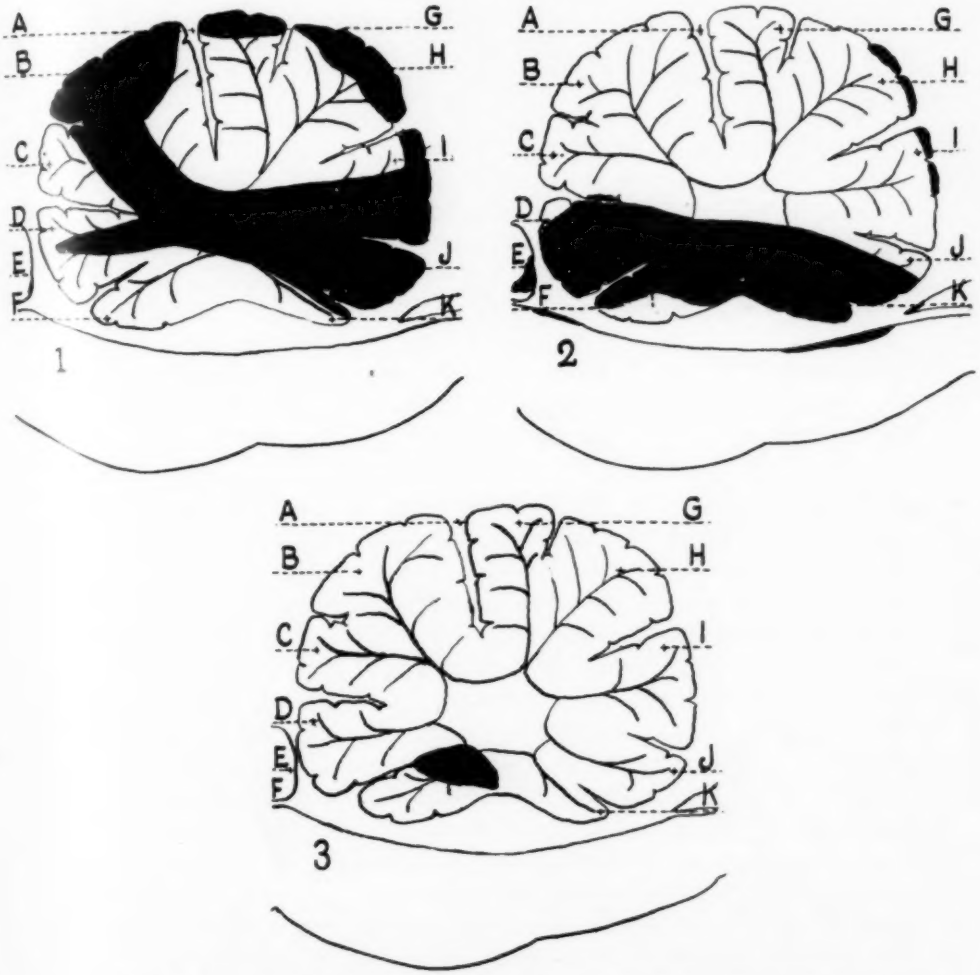


Fig. 17.—A composite diagram of the range of the lesions in *1*, all the dogs which did not show changes in the activities of the vocal cords after operation; *2*, all the dogs which showed specific motor disturbances in the vocal cords after operation and *3* the area of common involvement in all five such dogs.

the vocal cords than in the ones that did not. However, this was not true in all instances, as in dog 17 (fig. 10) the lobulus centralis was practically untouched. In figure 17, *3* shows the area of common involvement of the animals with changes in the vocal cords, and by

comparison with *1* it will be seen that this region was left intact in all of the animals in which such changes had not occurred. This area is the base of the lingula, but microscopic studies of frontal sections at this level show that the injury involves not only the base of the lingula but the neighboring tissues at the angle formed by the junction of the roof and the floor of the fourth ventricle (fig. 14). This is the area included in Meynert's "Innere Abteilung des Kleinhirnsteiles," or the *IAK*, and which includes the tractus cerebellonuclearis composed of ascending and descending fibers connecting the various nuclei of the medulla and the cerebellum.

The study of secondary degeneration of the fibers that have been cut in these lesions will form a separate report. In general, however, it may be said that the lesions were too high in the cerebellar system to make it possible to follow the course of the incoming (ascending or sensory) connections which may represent at least a part of the connections with which I am concerned. As to the outgoing (descending) fibers, an important system of tracts has been traced from the cerebellum to the brain stem which pass through or around the base of the lingula. The complexity of these is such, however, as to make it unwise to ascribe to them any functional relations at the present.

The functional disturbances were alike in all of the dogs, except in dog 14, in which they were of the same type but were present in the right vocal cord only and were associated with similar movements of the nostrils. In this animal the right mesencephalic root of the nucleus of the fifth nerve showed severe injury, and it has been suggested (Allen) that this nucleus subserves the function of muscle sense to certain muscles of the head and jaw. Incidentally, the study of the secondary degeneration of the tracts in these brains, which is to be reported in a separate paper, shows that this nucleus has direct connections with the cerebellar cortex; hence, it is possible that in this animal the same integrative system has been disturbed, though at a lower level, in which the connections are unilateral.

The question of the localization of an area in the cerebellar cortex for the control of the vocal organs has been under discussion for some time. As has been said, Bolk, in 1903, placed it in the lobus anterior with the bilaterally coordinated muscles of the face and head on the basis of comparative anatomic studies. Ingvar,[16] however, argued that since the function of speech belongs to the youngest (phylogenetically) of the animal series its control would therefore be expected to lie in the youngest part of the cerebellum, that part just below the sulcus primarius. It should be remembered in this connection,

16. Ingvar, Sven: Zu Kenntniss vom Einfluss des Kleinhirn auf die Sprache, Psychiat. en Neurol. Bl. **22**:329, 1918.

however, that disturbances of speech of cerebellar origin take the form of dysarthria and not of dysphasia; although speech is a recently acquired function, the use of the vocal cords in production of sound is an old function. In 1904, Jelgersma [17] called attention to the parallel development of the erect posture, dexterity and speech in man. All of these are dependent on highly developed muscle sense and motor coordination, functions which he allotted to the cerebellum; since the cerebellar hemispheres are most highly developed in man, he related erect posture, dexterity and speech to the hemispheres, and since the organs of speech are bilateral, he believed that cerebellar lesions which produce disturbances in speech must affect both cerebellar hemispheres. As a result of clinical experience, Bonhoeffer [14] holds the same view. From an analyses of his own clinical cases and others recorded in the literature, Stenvers [18] concluded that disturbances in speech might arise from unilateral lesions provided the lesion was placed on the right side in right handed, and on the left side in left handed, persons. In other words, he recognized a unilateral dominance in the cerebellar control of the organs of speech as well as in the cerebrum; but, in agreement with the crossing of the cerebellocerebral tracts, this dominance is placed on the opposite side from that of the cerebrum. This theory was refuted by Brouwer [19] who preferred the view of Jelgersma that the lesion must be bilateral and probably also must involve the vermis or paleocerebellum. From extensive experience with gunshot wounds of the cerebellum, Holmes [15] concluded that speech may be disturbed by lesions of any portion either of the vermis or of the hemispheres, although it is more liable to be severely disturbed when the vermis is injured.

One may conclude that lesions of any part of the cortex of the vermis, of the roof nuclei, or of the decussation between these nuclei do not produce changes in the function of the vocal cords in dogs, but that lesions to those tracts which connect the cerebellum with the medullary nuclei do produce motor disturbances of an ataxic type. Therefore, the cerebellum does appear to have some control over the motor activities of the vocal cords, though this control has not been localized in any particular part of the cerebellar cortex so far studied.

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17. Jelgersma: De physiologische Beteeknis van het Cerebellum, Amsterdam, K. Groesbeek and Paul Nijhoff, 1904.

18. Stenvers, H. W.: Klinische Studie over de Functie van het Cerebellum en de Diagnostik der Cerebellum en Brugg-Hoek Tumoren, Davo Deventer, 1920.

19. Brouwer, B., and Coenen, L.: Untersuchungen ueber das Kleinhirn, Psychiat. en Neurol. Bl. **25**:201, 1921.

THE NERVOUS MECHANISM OF RESPIRATION OF THE SELACHII *

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The problem of the respiratory mechanism of vertebrates has not been worked out completely in any group. In mammals, considerable progress has been made, but the subject is so complex that it is difficult of analysis. If the evolutionary history of this complicated mechanism were known, many unsolved phases of the problem might be made easier of approach. This knowledge would also be useful in furthering an understanding of natural selection and adaptation. Physiologists and neurologists have long disputed whether functional relations within the central nervous system have changed during the course of evolution or whether evolution has come about through the further elaboration, or dropping out, of connections which, so far as they exist in higher forms, have always retained their original position and function. The current view seems to be that the same divisions of the nervous system have the same functions in all types of vertebrates. Steiner,[1] von Monakow [2] and others have held that there has been a migration of function toward the anterior end of the central nervous system, although one seldom finds mention of this view in physiologic literature.

Attention is focused, therefore, on the respiratory mechanism in the lower vertebrates. Many factors of the mechanism have been

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1. Steiner, J.: Die Funktionen des Zentralnervensystems und ihre Phylogenese, Zweite Abt. d. Fische, Braunschweig, 1888, vols. 1-12.

2. Von Monakow, C.: Experimentälle und pathologisch-anatomische Untersuchungen über die Haubenregion, den Sehnugel und die Regio subthalamica, etc., Arch. f. Psychiat. **27**:1, 1895; Aufban und Localisation der Bewegungen beim Menschen, Leipzig, 1910.

studied in teleosts, and, to a lesser extent, in elasmobranchs. So far, however, no quantitative study of the general nervous control of respiration from the standpoint of its evolutionary significance in the phylum appears to have been made in either group. This problem was undertaken as the subject of investigation in the experiments described in this article.

Since the acquisition of oxygen, fats, carbohydrates and amino-acids must be regarded as initial and parallel stages in metabolism, it is not surprising that the simplest morphologic mechanism for respiration in vertebrates, as found in fishes, should be rather closely bound up with the alimentary system. Because of this relationship, which is further complicated by the presence of sensory and motor fibers in the same nerve trunks, the problem of the nervous mechanism of respiration in this group presents many difficulties. Furthermore, the animals vary as to age, size and vitality. Moreover, the fact that normal respiration seems to depend on a summation of both afferent nerve stimuli and chemical stimuli in the "respiratory center" makes it more difficult to obtain precise and definite results. It will be necessary, therefore, to increase greatly the number of experiments before many of the projected conclusions can be proved statistically. The data are reasonably consistent, however, and the number of animals used was so large that the observations recorded constitute at least a stepping stone for further and more extensive work on the subject.

Mustelus canis (Mitchell) and *Squalus acanthias* were used in most of the experiments. Some preliminary work was done on *Fundulus,* secured through the courtesy of the New York Aquarium, and also on *Ictiobus cyprinella* and *Cyprinus carpio.*

A large part of the research was done at the laboratory of the U. S. Bureau of Fisheries, Woods Hole, Mass.

HISTORICAL SURVEY

Among the early writers on the subject of respiration in fishes were the anatomists and physiologists Duméril,[3] and Duvernoy,[4] who described accurately the organs concerned in respiratory movements. Bert [5] was the first investigator to record graphically the movements of the mouth, pharynx and opercula in teleosts.

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3. Duméril, A. M. C.: Mémoire sur le mécanisme de la respiration des poissons, Nouv. bull. Soc. Philom. (Paris) **1**:20, 1807.

4. Duvernoy, G. L.: Du mécanisme de la respiration dans les poissons, Compt. rend. Acad. d. sc. **9**:75, 1839; L'Inst. **7**:232, 1839; Ann. sc. nat. **12**:65, 1839; Rev. mag. zool. 216, 1839; Compt. rend. Acad. d. sc. **8**:867, 1839.

5. Bert, P.: Leçons sur le physiologie comparée, professées au muséum d'histoire naturelle, Paris, 1870.

Using the work of Provençal and Humboldt [6] as a point of departure, Reynault,[7] Jolyet and Régnard,[8] Gréhant and Gréhant and Picard [9] found that when fishes were placed in boiled water, they continued to breathe for varying periods of time before becoming asphyxiated. These experimenters therefore concluded that these animals normally possess a reserve supply of oxygen. They observed also that respiration was not reestablished when the fishes were returned to normal sea water, if the region of the mouth (museau) was not immersed. This fact was interpreted as evidence that respiratory movements in fishes are due to continuous peripheral stimulation.

François-Franck [10] discovered that stimulation of the central end of the vagus brings about alterations of the respiratory movements in fishes.

Schoenlein and Willem [11] observed that the respiratory rate in selachians was in direct ratio to the volume of water flowing through the gill clefts in a given time. They also found that hemorrhage, or the plunging of animals into water not containing oxygen, did not produce symptoms of respiratory distress. These investigators concluded, therefore, that respiration was regulated by peripheral stimuli acting on a mechanism within the central nervous system (Hering and Breuer [12]).

An investigation of the mechanism of respiration in the elasmobranch fishes was conducted by Bethe,[13] who replaced sea water with a solution of 0.25 per cent cocaine in sea water. Respiratory movements were found to cease fifteen or twenty seconds later, and were not reestablished

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6. Provençal and von Humboldt, F. H. A.: Recherches sur le respiration des poissons, Mém. de phys. et de chemie de la Soc. d'Arcueil, Par. **2**:359, 1809.

7. Reynault, V.; Reiset, J., and Millon: Recherches chemiques et physiques sur le phénomène de la respiration dans le divers classes des animaux, Compt. rend. Acad. sc. **36**:4 and 17, 1848.

8. Jolyet, F., and Régnard, P.: Sur une nouvelle methode pour l'étude de la respiration des animaux aquatiques, Compt. rend. Acad. d. sc. **82**:1060, 1876; Recherches physiologiques sur la respiration des animaux aquatiques, Arch. de physiol. norm. et path. **9**:584, 1877.

9. Gréhant and Picard: De l'asphyxie et de la cause des mouvements respirations chez les poissons, Compt. rend. Acad. d. sc., 1873, vol. 76.

10. François-Franck, C. A.: Travaux du laboratoire de Marey. Recherches sur les effets produits par l'excitation du bout central du pneumogastrique et de ses branches sur le respiration, le couer, et les vaisseux, Paris, 1880; Mécanisme respiratoire des poissons téléostiens: I. Technique des explorations graphiques: II. Technique des prises de vues photochronographiques dans l'étude de la mécanisme respiratoire des poissons téléostiens, Compt. rend. Soc. de biol. **60**:962, 1906.

11. Schoenlein, K., and Willem, W.: Beobachtungen uber Blutkreislauf und Respiration bei einigen Fischen, Ztschr. f. Biol. **32**:511 and 547, 1895.

12. Hering, E., and Breuer, J.: Die Selbsterneuerung der Athmung durch den Nervus vagus, Sitzungsb. d. Wien. Akad. **57**:672, 1869.

13. Bethe, A.: Allgemeine Anatomie und Physiologie des Nervensystems, Leipzig, G. Thième, 1903.

for several minutes after the fish was put back into normal sea water. Bethe believed that this cessation of respiration was due to a lack of stimuli normally coming from the oral cavity. The same investigator likewise made other observations which indicated that central as well as peripheral factors were involved in the respiratory processes.

Hyde [14] found that the respiratory center in the skate occupied definite sensory and motor areas in the medulla.

Van Rynberk [15] repeated Bethe's work on cocaine and concluded that the respiratory cessation was caused by a general narcosis. This author was convinced, however, that the control of respiration was partly peripheral and partly central in nature.

Baglioni [16] found that after the head of a shark was severed from the body and removed from the water, respiratory movements continued for a period of time which could be extended if the brain was laid bare and a supply of oxygen made available. Baglioni later showed that the respiratory mechanism in fishes responded to stimulations of the mucous membranes by the "expulsion reflex."

Ishihara [17] and Westerlund [18] found that respiratory movements continued after the administration of cocaine to the mucous membranes in the region of the mouth and gills.

Babák [19] worked with his pupil Dědek on several teleosts. They observed clearly defined cases of apnea and dyspnea.

Kuiper [20] made a careful study of the different phases of respiratory movements in teleosts, and of alterations produced by changes of such factors as temperature and gas pressure.

Lombroso [21] observed that respiration continued normally when fishes were placed in oil. He therefore concluded that contact with water was not a specific stimulus.

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14. Hyde, Ida H.: Localization of the Respiratory Center in the Skate, Am. J. Physiol. **10**:236, 1904.

15. Van Rynberk, G.: Richerche sulla respirazione dei pesci. (Note I, II, III). R. Acad. Nazionale dei Lincei, Classe di Scienze fis., mat., e nat., Rome **15**:443, 530 and 708, 1905.

16. Baglioni, S.: Ueber das Sauerstoffberdürfnis des Zentralnervensystems bei Seetieren, Ztschr. f. allg. Physiol. **5**:415, 1905; Cangiamenti fisiologici nella meccanica respiratoria dei pesci fuori d'acqua, Atti del III Congresso Nazionale di Pesca in Milano, Sept. 19-23, 1906, in Milano, 1908, p. 1.

17. Ishihara, M.: Bemerkungen über die Atmung der Fische, Zentralbl. f. Physiol. **20**:157, 1906.

18. Westerlund, A.: Studien über die Atembewegungen der Karausche, Skand. in Arch. f. Physiol. **18**:263, 1906.

19. Babák, E., and Dědek, B.: Untersuchungen über den Auslösungsreiz der Atembewegungen bei Süsswasserfischen, Arch. f. d. ges. Physiol. **119**:483, 1907.

20. Kuiper, T.: Untersuchungen über die Atmung der Teleostier, Arch. f. d. ges. Physiol. **117**:1, 1907.

21. Lombroso, U.: Ueber einige besondere Regulationsvorgänge der Atmungsvorgänge bei Knockenfischen, Arch. f. d. ges. Physiol. **119**:1, 1907.

Degannello [22] published the results of extensive experiments on teleosts, but it does not appear that he gave enough definite data in support of his conclusions. In the first series, he studied modifications of rhythm brought about by sectioning or tearing each of the cranial nerves on one or both sides. Following section of the superior maxillary branch of the fifth cranial nerve and the vagus, the respiratory rate was decreased. These nerves, therefore, were considered to have a "tonic" effect on the respiratory center. The second series of experiments emphasized the importance of peripheral stimulations of the mucous membranes of the mouth and lips in the determination of reflex respiratory movements.

EXPERIMENTAL METHODS

Unless otherwise stated, the fishes used in the experiments cited were *Mustelus canis* (Mitchell) and *Squalus acanthias*.

When brought to shore, the fishes were placed in a trap under a float open to the tide. For a short time after the experiment they were kept in aquaria, but were finally transferred to a second trap outside. Since there was considerable variation in vitality, 207 animals were used in compiling the data. Most of the experimental work was done in the hatchery room of the Woods Hole Bureau of Fisheries. The temperature of this room seldom varied considerably from the temperature of the water in the circulation.

While a typical experiment was being performed, the fish was placed on its ventral side on a movable grooved board which formed the central part of a specially constructed water table. Strips of canvas fastened across the body at intervals held it securely in position. If the fish proved to be unusually restless, a piece of canvas fastened at one side of the grooved board, with its free end weighted with a heavy lead pipe, was adjusted to cover the body. The snout was wrapped in a pad of cotton wool wet in sea water, and was held in position by a clamp shaped to fit closely over it. Sometimes an experiment was conducted with the fish on its back. A *V*-shaped trough, with a gap at the apex of the *V*, was then substituted for the grooved board. In order to secure freedom of action in the region of the mouth and gills, the anterior part of the fish from the nose clamp to the last arch of the gills was unsupported.

The respiratory current was furnished through a rubber hose. A second stream of water was kept flowing over the animal. Another method of supplying the respiratory current was tried as a check on this method. The fish's head was placed in a large battery jar, the top of which had been cut off obliquely in such a way that on tilting the jar the region of the mouth and gills was completely submerged. The snout was then held in place by a noose. The fish was somewhat difficult to manage under these conditions, however, and since the results so obtained corresponded closely with those given by the first method, the second method was used only as a check.

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22. Degannello, U.: Die peripherischen, nervosen Apparate des Atmungsrhythm bei Knochenfischen, Arch. f. d. ges. Physiol. **123**:40, 1908.

In many experiments, it was necessary to know the approximate pressure of the current of water entering the mouth. A simple dial pressure gage was therefore employed which made it possible to produce, or to duplicate, a given strength of current. The strength of the respiratory current used was adjusted to the particular fish under observation. At the beginning of each experiment, the respiratory rate was determined in the outside trap or in the aquarium. A volume of water which would maintain the rhythm at approximately the same rate was then used when the fish was placed on the water table. Experimental procedures were not begun until the rate had become constant. The pressure in the circulation of water was maintained by an electric pump.

A series of light weight spring levers was employed in making precise observations on the respiratory movements. By means of S-hooks and silk thread the levers were attached to the first, second and fourth gill covers of one side. The movements of the mouth were recorded with similar apparatus, aided by pulleys and a small fishhook piercing the skin of the lower lip. The movements of the four levers and those of a Jacquet chronograph and a signal magnet were recorded on a kymograph.

The respiratory movements of each animal were recorded before the preliminary dissection was started. A second record was made after the dissection was completed, and a third record was obtained to show the effects of section or stimulation of certain parts. The second record may easily be compared with the third, because the animal was so placed before the final section that at the opportune moment the last stage of the operation could be carried out without altering the position of either the animal or the apparatus.

Dry cells in connection with a Porter inductorium supplied electric current when needed. For electrical stimulations of the areas of the brain and nerve trunks, small shielded electrodes were used. For stimulations of the skin or of the body musculature, zinc plate electrodes were used. Pointed wads of cotton, glass rods or pinching forceps provided means of mechanical stimulation.

Transections of the brain were made with hot steel needles or by a cataract knife or a bistoury. Nerves were cut by the cataract knife or with scissors.

At death the animals used in the experiment were placed in formaldehyde, and a postmortem examination was made.

Preliminary experiments were carried out on *Fundulus* to test the practicability of using magnesium sulphate as a local anesthetic. As it was necessary at times, however, to apply the substance to a large part of the region of the gills, its use seemed unwise. In some other experiments ether was given, but in most cases this procedure was impracticable. Patience, sharp instruments and a minimal amount of trauma sufficed to keep the animals tractable during the experiments.

The results of a large number of experiments, but only those in which the graphic records were fairly complete, are presented in the form of graphs. These have been plotted from the means calculated from the values obtained at the end of each interval. The mean deviations of the mean were calculated according to the formula

$$\sigma = \sqrt{\frac{\Sigma(\delta)^2}{N(N\text{-}1)}}$$

where σ equals the mean deviation of the mean; (δ) the arithmetical difference between the individual determinations and the mean for the series and N, the number of observations (Flinn and Scott[23]).

23. Flinn, F. B., and Scott, E. L.: Some Effects of Various Environmental Temperatures upon the Blood of Dogs, Am. J. Physiol. **66**:191, 1923.

EXPERIMENTAL RESULTS

NORMAL RESPIRATION

In the study of the normal respiration of the elasmobranch fishes, a great deal of controversy has arisen concerning: (1) which movements are inspiratory and which expiratory; (2) how the movements of the different parts of the apparatus are related at different times, and (3) what course the respiratory current takes during inspiration and during expiration.

From a careful study of the respiratory records obtained under various conditions, and from observation of the movements, it seems clear that in dogfishes the respiratory current is produced by the forcing of water through the mouth into the pharynx and gill pockets and then out through the gill clefts by means of a complicated series of buccal and pharyngeal muscles. When the mouth opens, the gill clefts are closed in such rapid succession that at the normal rate they appear to be closing simultaneously. The floor of the buccal and pharyngeal cavities is lowered. The water rushes into these enlarged cavities; this is the inspiratory phase. The mouth is then closed by the adductor muscles of the mandible which at the same time expand the arches of the gills. Water is drawn into the gill pockets thus enlarged and forced out through the gill clefts by the contraction of the muscles of the arches; this constitutes expiration. Repetition of this process results in a rhythm which varies in rate according to the age, size and physical vigor of the fishes. In adult fishes at rest the rate varied from thirty to sixty respirations per minute. In young fishes, variations of from thirty to eighty were found. These observations are in general accord with those of a number of other investigators.

PRESSURE OF RESPIRATORY CURRENTS

Under experimental conditions the volume of water flowing through the mouth and gill clefts in a unit of time is directly proportional to the pressure of the current led into the mouth. In general, the stronger the current, the greater is the rate of respiration, unless the current is extremely strong or weak for a given fish. The respiratory rate in a young fish seemed to be more responsive to changes in the pressure of the respiratory current than that in an older fish. There is, however, in all fishes an individual point of equilibrium to which the rate returns after a certain period of time even when currents of moderate pressures are used.

It may be that fatigue of the afferent nerve endings is a factor to be considered, since the rate does not change much on change of current after the animal has been subjected to varying currents for some time.

The effect of varying the pressure of the respiratory current was studied after section of the maxillary branch of the fifth nerve, of the palatine branch of the seventh nerve and of the ninth nerve. Marked results were not noted; however, if moderate currents were used after section of the vagi, little, if any, change of rate followed a change of currents. When extremely strong or weak currents were used, the rate was greatly affected for some seconds, possibly because of the increased inertia of the posterior arches of the gills.

No considerable apnea or dyspnea appeared to be produced in any of the experiments by an increased or by a decreased respiratory current. Such complications, which might conceivably be brought about through the artificial regulation of the respiratory current, probably need not, therefore, be taken into consideration in these experiments.

In many experiments, especially those in which a series of changes of respiratory currents involving extremely strong or weak currents had been used, the blood vessels on the ventral surface and along the edges of the fins became greatly dilated. In extreme cases, the blood seeps from the edge of the tail fin in drops; in other cases, blisters of blood appear along the surface of the fins. This condition seems to be induced by capillary hemorrhage. At autopsy, the hemorrhage in these cases was observed to be extensive, not only in the outer parts of the body but also in the mesentery and in the organs of the abdominal cavity. This recalls an old observation made, it is said, by Newall Martin, in which a dilatation of the blood vessels in the web of the frog's foot was shown to be brought about by stimulation of the afferent nerve endings in the tongue. One notes also that Biedermann is said to have found an appearance of edema in the tongue of a frog on stimulation of the trunk of the ninth and the eleventh cranial nerves. Anrep and Evans [24] also showed that vasodilatation in the tongue follows stimulation of the peripheral end of the lingual nerve. Krogh [25] found that urethane applied locally, or weak local mechanical stimulation, causes dilatation in the frog's tongue. According to this observer, section of the nerves does not abolish capillary tonus, but it disappears when the blood supply is cut off. It is probable, in view of this work, that a thorough study of the effects of hemorrhage in the dogfish could profitably be made. It is all the more interesting, however, that the capillary dilatation already described usually occurred in the absence of any operative procedures.

At least two explanations of this phenomenon in the dogfish present themselves. Changes in the gaseous content of the blood might bring

24. Anrep, Gleb; and Evans, C. L.: The Mode of Action of Vasodilator Nerves, Proc. Physiol. Soc. in J. Physiol. **54**:10, 1920.

25. Krogh, A. A.: Studies on the Capillariomotor Mechanism, J. Physiol. **53**:399, 1920.

about changes in the permeability of the capillary walls, or the hemorrhage might accompany a reflex set up by stimulation of vasodilator nerve endings in the buccal and pharyngeal membranes. More extensive capillary hemorrhages occurred when strong respiratory currents were used. Since the H-ion concentration of the blood would presumably be low under such circumstances, the permeability of the capillary walls probably would tend to be decreased rather than increased. The hemorrhage, therefore, may have been caused by excessive stimulation of a vasodilator mechanism for which some evidence was obtained to show that the vagus may be the most important afferent channel. These observations suggest that adjustments in the blood pressure may be necessary when the respiratory membranes of fishes are brought into contact with strong currents in swimming.

THE EFFECT OF DRUGS

Experiments were performed to determine whether the muscles of respiration in fishes react to certain drugs as do the skeletal muscles of mammals. This point is of interest since in the latter the principal muscles of respiration are metameric in origin, while in fishes these muscles are branchiomeric.

The first series of experiments dealt with the effect of strychnine sulphate. The method consisted in placing a fundulus, 3 inches (7.6 cm.) long in each of ten dishes containing 500 cc. of sea water. Strychnine sulphate was added to these dishes in such quantity as to make a series of concentrations varying from 0.00043 per cent, a nonlethal dose, to 0.0086 per cent, a lethal dose. Controls were kept.

No effect on respiration was noted for one and one-half hours. A small portion of cake was then crumbed into the dishes. The effect of the strychnine was evidenced within a few minutes after the fish had eaten the crumbs moistened in the stronger solutions. There was a loss of muscular control and increased irritability. Respiration first became spasmodic, then labored. Paralysis of all the muscles of the body gradually followed. The rate and the amplitude of respiration became greatly reduced, while the power of response to stimulation disappeared. When death occurred, the muscles of the mouth and of the operculum were found to be characteristically rigid. Strychnine does not seem to be absorbed through the mucous membranes of the mouth or the respiratory surfaces of the gills, nor does the fish appear to swallow any of the "respiratory" water.

A second series of experiments dealt with the effect of caffeine on the respiratory musculature. The method was the same as that described when strychnine was used, the concentrations varying from 0.02, a lethal dose, to 0.002 per cent, a nonlethal dose.

Caffeine is absorbed through the mucous membranes of the mouth and gills in Fundulus. Paralysis of the muscles of respiration was noted in the lethal concentrations. Respiration slowly ceased. On its cessation, the respiratory musculature was found to be in a state of tonic rigidity.

STIMULATION OF BODY AREAS

The question naturally arises as to what influence pressure in various regions of the body, such as was exerted by the nose clamp or the canvas strips, might have on the respiration. After a sufficient time had elapsed for the respiratory rate to become constant, the pressure of the clamp was altered. The amplitude and also the rate of the respiratory movements were somewhat changed, but in all cases noted they returned to normal within one minute. This perhaps furnishes another illustration of du Bois-Reymond's law of stimulation.

In line with this observation was that made on the effect of pressure on the lateral line regions of the trunk and head. Here, as Parker [26] found, a retardation of respiration occurs if pressure is applied. In this case also, if the stimulus is continued for several seconds, or if it is applied gradually, a respiratory effect was not observed.

Stimulation of areas on the head, spiracle and the region of the gills by pressure with a glass rod, or by the pressure of a strong current of water, frequently results in reversal of the respiratory current—the "expulsion reflex."

An attempt was made to investigate the effect of stimulation of the afferent nerve endings in the musculature of the body. To do this the skin was removed at various regions over the adductor muscle of the mandible (magnesium sulphate being used as a local anesthetic) and over the musculature along the trunk considerably above and below the lateral line. A small glass shielded electrode was inserted into the muscle. Rapid make and break stimuli were applied. Pinching the muscle with small forceps was also tried. The respiratory movements became irregular and at times slightly retarded. This may indicate the presence of afferent nerve endings in these muscles in view of the fact that later experiments seemed to show the afferent system to be involved in the control of respiratory movements. Even with the skin removed, however, one cannot be sure that afferent nerve endings were stimulated and not nerve twigs belonging to the lateral line system, although it must be noted that Sherrington's [27] researches on the desensitized limb of the

26. Parker, G. H.: Influence of the Eyes, Ears and Other Allied Sense Organs on the Movements of the Dogfish, Mustelus Canis (Mitchell), Bull. U. S. Bur. Fisheries **29**:43, 1909; Parker, G. H., and Shelden, R. E.: The Sense of Smell in Fishes, Bull. U. S. Bur. Fisheries **32**:33, 1912.

27. Sherrington, C. S.: Note on the Correlation of Action of Antagonistic Muscles, Proc. Roy. Soc., London **53**:409, 1893.

cat showed that the nerves of the skin do not play an indispensable part in muscular movement. The results which followed stimulation of the adductor muscle of the mandible must also be weighed with full appreciation of the fact that this muscle is of great importance in movements of the mouth. Mechanical stimulation may simply interfere with its proper mechanical functioning.

TRANSECTIONS AND STIMULATIONS OF CRANIAL NERVES

The Olfactory Tract.—Unilateral or bilateral section of the olfactory tracts in the cranium and electrical or mechanical stimulation of their central end do not affect respiration.

An effort was made to determine whether, when such substances as ether, chloroform, chloral and ammonia, which have a pronounced effect on respiration in mammals, are placed in the olfactory capsules, they influence the respiratory movements of fishes. Before a given substance was applied to the olfactory capsule, the fish was placed on its back. A piece of sheet rubber smeared with petrolatum fitted over its nose prevented the reversal of the respiratory current from flooding the capsule. Only one capsule was treated at a given time, and the same one was treated only once.

Before an experiment was begun, it was necessary to remove the water from the capsule. This was done by using a cotton swab. The procedure produced a definite respiratory effect, which section of the olfactory tracts did not abolish. This effect is apparently the same as that later found to accompany section or stimulation of the central end of the maxillary branch of the fifth cranial nerve, consisting of a decrease in the respiratory rate and a reversal of the respiratory current which may be followed within from thirty to sixty seconds by a rate slightly above normal. The amplitude of the respiratory movements may also be decreased by swabbing out the capsule. No result followed in three cases in which the fifth nerve had been cut in the orbit on the preceding day. These observations furnish further evidence that the olfactory capsules contain fibers from the fifth cranial nerve (Sheldon[28]). Slight changes in pressure within the olfactory capsule, such as those caused by the sudden liberation of fluid from a pipet, have the same effect on respiration, but it is less marked.

Specific respiratory effects did not occur on the slow liberation of ether, chloroform or chloral into the olfactory capsule. Within thirty seconds after its introduction into the capsule, ammonium hydroxide produced convulsive respiratory movements and a slight and temporary decrease in rate.

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28. Sheldon, R. E.: Reactions of the Dogfish to Chemical Stimuli, Comp. Neurol. **19**:273, 1909.

The Fifth Cranial Nerve.—1. Maxillary Branch (chart 1): The fifth cranial nerve was cut in the orbit by an incision in the roof of the mouth (Lyon's method). It appears that its unilateral section in the orbit usually results in a reversal of the respiratory current for one or two phases, a slight decrease in rate and a slight decrease in the amplitude of the movements of the mouth. If these respiratory effects follow unilateral section, bilateral section generally has little added effect. If, on the other hand, unilateral section has little effect, bilateral section usually has a more marked effect. Within an hour at the most the respiratory movements appeared to be normal.

Mechanical or electrical stimulation of the distal end of the maxillary branch of the fifth cranial nerve does not have any effect on respiration. Stimulation of the central end is attended by irregularity of rhythm and a reversal of the respiratory current, usually accompanied by a slight decrease in rate and amplitude immediately following the application of the stimulus.

2. Superior Ophthalmic Branches of the Fifth and Seventh Cranial Nerves: When the nerve formed by the union of these two branches is cut at the point at which it emerges from the cranium, a marked contraction of the musculature of the mouth results, with the production of spasmodic respiratory movements usually disturbing from two to six respiratory phases. When the nerve is cut on one side, the rate may be slightly decreased for a few seconds, but the amplitude of the movements usually is not affected. Bilateral section may slightly decrease both the rate and amplitude of the movements of the mouth for from fifteen to thirty seconds.

Stimulation of the distal end of this nerve does not have any effect. Stimulation of the central end has the same effect as section of the nerve. The mouth opens wider if the stimulus is applied when the muscles of the mouth are relaxing, and the gill covers contract more forcibly if the muscles of the mouth are contracting.

The Seventh Cranial Nerve.—1. Palatine Branch: This nerve was approached and cut in the roof of the mouth. The only effect on respiration noted was slight irregularity of rhythm during section.

2. Hyomandibular Branch: This nerve was exposed and sectioned at the outer edge of the spiracle. The nerve twigs given off as the nerve leaves the cranium were ligated with a seeker and cut. These small twigs function in the movement of the muscles of the floor of the buccal cavity, but the decrease in the amplitude of movement of this region following their section was not sufficiently great to affect the respiratory movements as recorded.

Unilateral or bilateral section of the hyomandibular nerve usually results only in irregularity of the respiratory movements during section

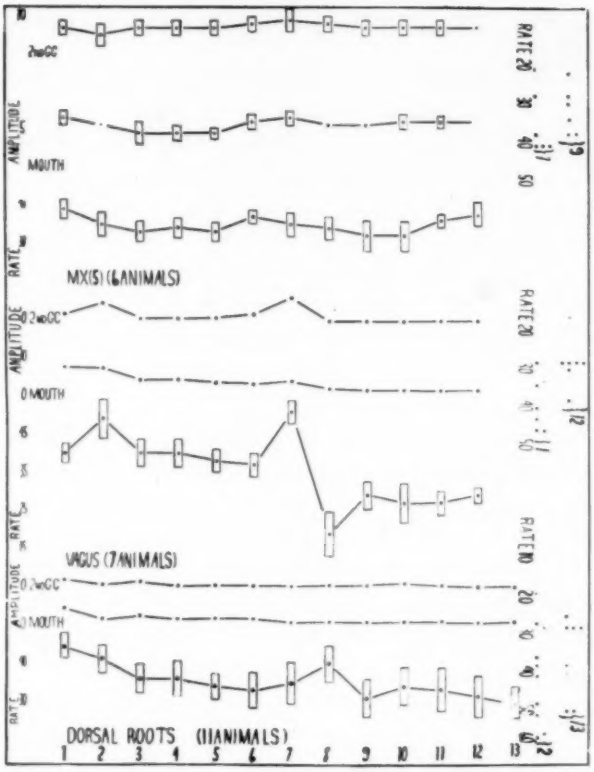

Chart 1.—Effect of transection of dorsal roots, vagus and MX (5). The arithmetical means of the respiratory rates and of the amplitudes are plotted in millimeters at the end of each interval of time. These intervals are numbered consecutively from 1 to 13 in this chart. Vagus and MX (5): *1*, one minute before section; *2*, section of right nerve (unilateral section); *3*, ten seconds after section of right nerve; *4*, thirty seconds after section of right nerve; *5*, one minute after section of right nerve; *6*, from two to five minutes after section of right nerve; *7*, section of left nerve (bilateral section); *8*, ten seconds after section of left nerve; *9*, thirty seconds after section of left nerve; *10*, one minute after section of left nerve; *11*, five minutes after bilateral section and *12*, from five to ten minutes later. Dorsal roots: *1*, one minute before spinal cord was exposed; *2*, one minute before section of roots of right side (unilateral section); *3*, section of roots of right side; *4*, ten seconds after section of roots of right side; *5*, thirty seconds after section of roots of right side; *6*, one minute after section of roots of right side; 7, from two to five seconds after section of roots of right side; *8*, section of roots of left side; *9*, ten seconds after section of roots of left side; *10*, thirty seconds after section of roots of left side; *11*, one minute after section of roots of left side; *12*, five minutes after section of roots of left side (bilateral section) and *13*, fifteen minutes later.

The mean deviations of the mean are shown by boxes in all cases for the respiratory rates; but only for the amplitudes of the mouth and second gill cover when the mean deviation of the mean was more than 1.5 mm. in extent.

On the left side of each chart is given the frequency distribution of the respiratory rates of the individual animals, each of which is represented by a dot. The lower group represents individual respiratory rates before transection; the upper group represents the respiratory rates of the same animals at the indicated interval after transection.

if the other cranial nerves are intact. In four of twenty cases, the movements of the first and second gill covers decreased slightly in amplitude, while the movements of the mouth increased slightly (compensation?) following bilateral section of this nerve.

Stimulation of the central end of this nerve causes retardation of the respiratory rate during the period of stimulation. There may be a cessation of movement for from five to eight seconds. In three cases, a reversal of rhythm of all the respiratory movements occurred after stimulation.

Stimulation of the distal end of this nerve causes contractions of the first arch of the gills with movements of the spiracle and first and second gill covers.

The Ninth Cranial Nerve.—The ninth cranial nerve was exposed in the otic capsule or as it emerged from it. At transection the respiratory rhythm is slightly disturbed by irregular and exaggerated movements of both the mouth and the gill covers. From one to three respiratory phases are thus affected. No change in rate or amplitude follows the section, on one or both sides, if the other cranial nerves are intact. Transection of the ninth nerve usually produces a slight decrease in the amplitude of movement of the first and second gill covers if the vagus on the same side has been cut previously.

Electrical or mechanical stimulation of the peripheral end of the ninth nerve causes contractions of the first and second gill covers. Stimulation of the central end produces irregularity with retardation lasting from one to six respiratory phases.

The Tenth Cranial Nerve (chart 1).—The vagus nerve was usually approached and cut in the otic capsule, but since this procedure caused a slight decrease in the tone of the respiratory muscles of the same side, in some cases the nerve was cut as it emerged from the capsule at the posterior end of the chondrocranium. In other cases it was found advisable not to expose the nerve trunk, but to cut it through a thin layer of cartilage with a sharp scalpel.

Unilateral section of the vagus usually, and bilateral section of the vagi always, results in a decrease in both the rate and the amplitude of respiration. In most fishes the rate returned to normal after a variable length of time, but the amplitude did not.

At the time of transection there is always a great disturbance of the respiratory rhythm. The movements of both the mouth and the gill covers become irregular and spasmodic, and always become slower if they do not actually stop. Cessation of respiration may continue for several phases after the section. Although there is no lack of coordination in the respiratory movements after section of the vagi (with moderate currents), the amplitude of the movements of the mouth is

especially affected. This definite decrease of tonus is emphasized by the fact that after the vagi are cut in such experiments, a fish does not respire easily on its back, a position in which the muscles of the mouth must overcome added resistance.

After section of the vagi, at least two posterior gill covers cease to move. The two gill covers anterior to these move with less amplitude, but do not stop moving, presumably because the seventh and the ninth nerves share in the innervation of the muscles of respiration.

As in the case of the maxillary branch of the fifth cranial nerve, the influence of the vagi on the respiratory processes seems to be limited. If unilateral section produces a considerable decrease in rate and amplitude, bilateral section produces little additional effect. The converse is likewise true.

Mechanical or electrical stimulation of the distal end of the vagus causes movements of the four posterior gill covers. If the stimulus is sufficiently strong, these movements are spasmodic; if the stimulus is weak, the rhythm may not be greatly disturbed, but the movements are augmented.

Stimulation of the central end of the vagus causes a retardation of respiration, varying according to the strength of the stimulus. There may be a total cessation of respiration after stimulation, but this cessation was never observed to continue for more than ten seconds.

In three experiments in which the lateral line component of the vagus was cut, a respiratory effect was not observed.

Combined Transection of Cranial Nerves.—After a study of the effects on respiration of section of the individual cranial nerves, a series of experiments was performed to discover whether significant relationships existed between these nerves. A high degree of coordination was necessary for the performance of normal respiratory movements. At the same time, a large margin of safety is insured by the fact that respiratory movements can be maintained after loss of a considerable part of the motor innervation of the respiratory mechanism. For instance, with only the vagus on one side, and the small nerve twigs from the hyomandibular seventh nerve on the other side, a slight respiratory current can be maintained for as long as an hour. There is in general a compensatory action of the muscles of the mouth and gill cover.

Simultaneous stimulation of the central ends of the tenth and the seventh cranial nerves causes a greater retardation or cessation of respiration than stimulation of the tenth nerve alone. Stimulation of the central ends of the ninth and the tenth cranial nerves causes little, if any, greater retardation than stimulation of the tenth nerve alone, but a much greater retardation than stimulation of the ninth nerve alone.

Stimulation of the central end of the superior ophthalmic branch of the fifth cranial nerve and of the seventh nerve in most cases causes a slightly greater retardation than stimulation of either nerve alone. Stimulation of the central ends of the seventh and the ninth nerves usually does not cause greater retardation than stimulation of the seventh nerve alone. A greater retardation is produced than that noted when the ninth nerve alone is stimulated.

TRANSECTIONS OF THE BRAIN

The brain was exposed with minimum trauma of the skin and cartilage and removal of the connective tissue, embryonic in type, which occurs within the cranium of the dogfish.

Cerebral Hemispheres (chart 2).—Transections of the cerebral hemispheres always result in convulsive respiratory movements, the maximum extent of which occurs at the midway point of the transection. The movements of the gill covers were relatively more disturbed than those of the mouth during the transection. The slight increase in rate, shown in the chart to follow transection of the cerebral hemispheres, is due to marked acceleration which occurred in four of thirteen cases. It is possible that slight tearing of the tissues may have been the cause of the acceleration in these cases.

Removal of the cerebral hemispheres did not produce a noticeable effect on the swimming movements of the animals, which usually lived in the outside trap for from six to twelve days following the operation.

Weak or moderate electrical or mechanical stimulation of the surface of the cerebral hemispheres does not have any effect on respiration.

Thalamus (chart 2).—Transection of the thalamus at various levels always results in a disturbance of the respiratory rhythm and convulsive respiratory movements during the operation. As in the case of the cerebral hemispheres, the amplitude of the gill cover is increased during transection to a greater extent than is the amplitude of the mouth.

In many experiments (eighteen of thirty-seven) transection of the thalamus was followed by acceleration of the respiratory rate, thus producing a slight rise of the curve in the chart. An effort was made to locate the exact region in which transection would produce this effect, but there appeared to be no constancy of location. If the transection involved tearing of the tissues, there might be an increase in the respiratory rate. It is then, however, difficult to understand why, with the same methods of section, an acceleration following transection of the caudal end of the cerebral hemispheres should occur only occasionally. Electrical stimulation of the floor of the thalamus sometimes results in a similar acceleration of rate.

The motor disturbance produced by section of the thalamus may at times be extensive, and even rhythmical, involving a large part of the body musculature. This is probably due to stimulation of motor fibers in this region. Weak electrical or mechanical stimulation of the surface of the thalamus has no effect on respiration.

Optic Lobes (chart 3).—Transections of the anterior third of the optic lobes result in convulsive and exaggerated respiratory movements

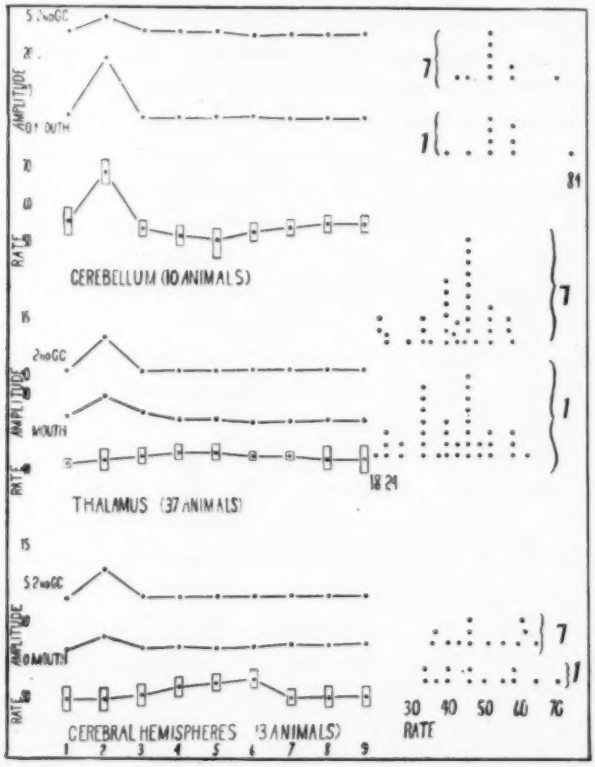

Chart 2.—Effect of transection of cerebral hemispheres, thalamus and cerebellum. In this and in chart 3 the intervals of time, numbered consecutively from 1 to 9, are as follows: *1*, one minute before transection; *2*, transection; *3*, ten seconds after transection; *4*, twenty seconds after transection; *5*, thirty seconds after transection; *6*, forty seconds after transection; *7*, one minute after transection; *8*, one and one-half minutes after transection and *9*, five minutes after transection.

for several phases. The movements of the mouth are especially affected. If the section is made when the mouth is beginning to close and the gill covers are beginning to relax, these movements are augmented, and vice versa. The rate may be slightly decreased. The amplitude of the movement of the mouth is usually decreased following the transec-

tion, while that of the gill covers is unaffected. Transections through the posterior third of the optic lobes likewise result in irregular respiratory movements the coordination of which is nevertheless undisturbed. As shown in chart 3, there seems to be a decrease in the respiratory rate, and the amplitude of the movements of the mouth may be reduced. The farther posterior the transection, the greater is the effect on the respiratory mechanism.

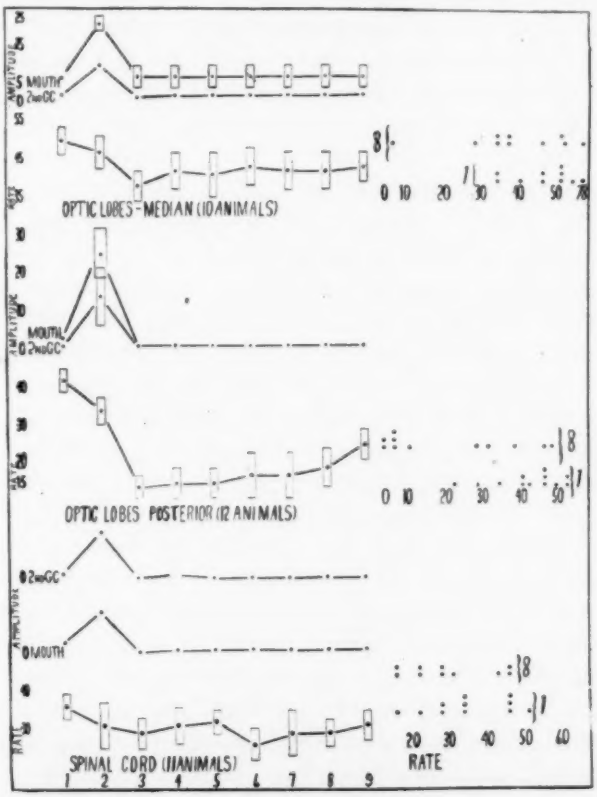

Chart 3.—Effect of transection of spinal cord and optic lobes (posterior and median).

From a study of data shown in chart 3 and from an analysis of fifteen other cases not used in the charts because the graphic records were not entirely complete, it appears that transections at the junction of the optic lobes and hindbrain usually result in a decrease in both the rate and the amplitude of respiration. There may be a total cessation of respiration for as long as five minutes. Usually the rate is restored to its former level, or as in four cases, rises slightly above it, within five minutes, while the amplitude may never be restored. In most cases after a few minutes the fish was placed in an aquarium to recover from

the operation. This necessitated a readjustment of the apparatus, making it difficult to judge the postoperative amplitude when the fish was again placed on the operating board. The variations in effects noted following transections at the posterior end of the optic lobes may be due to differences in the physical condition of the animal or to the exact location of the transection; for the more severe effects were encountered when the region of the medulla (cephalic portion of the pons), which gives rise to the complexes of the fifth and seventh nerves, was encroached on. If the respiratory effect, however, was due to a gap in the pathways of the motor nerves, it is difficult to explain why, after transection at the posterior end of the optic lobes in three cases, the fish breathed only if vigorously stimulated by stroking the gill covers or the caudal fin.

After transection at the posterior end of the optic lobes, the entire midbrain was usually removed and a cotton plug inserted. The decreased mortality which followed the use of such a plug may have been due to the absorption of blood by the cotton, thus preventing a clot from forming on the ventral surface of the medulla. Indeed, it was twice observed that respiration, which had ceased following transection of the brain at the posterior end of the optic lobes, began again after the blood clot was removed. The fish was then placed in the trap under the float, where it lived for several days, six in one instance. Such fishes showed a curious swaying motion of the posterior parts of the body similar to that following transection of the spinal cord. They exhibited little, if any, spontaneous movement; in fact, the only movement noted was a change in position during the night from one end of the trap to the other (moved by the tides?). The animal usually lay quietly on the bottom of the trap, but would move off when the tail was pinched.

In the case of both the dogfish and the Fundulus, after removal of the cerebellum and transection of the optic lobes at their posterior end, the fishes swam in spirals when the transections were asymmetrical. There was a tendency for them to lie on their backs following transection at the middle or at the posterior part of the lobes. In Fundulus, asymmetrical transections of the optic lobes produced a similar effect.

In several cases there was a disturbance of the bodily musculature after transection of the optic lobes, especially at their junction with the metencephalon. This sometimes resulted in rhythmical respiratory irregularities, somewhat like Cheyne-Stokes respiration. Death followed such symptoms.

Anteroposterior transection of the optic lobes does not have any significant effect on the respiration.

Striking loss of tone was not observed to follow transection at the anterior or middle region of the optic lobes. A slight limpness of the body may occur after transection at the posterior end of the optic lobes.

Nystagmus occurs under varying conditions of experimentation on the brain, but is particularly evident during transection or stimulation of the optic lobes.

In four experiments, section of the vagi was followed by transection at the caudal border of the optic lobes. Respiration ceased in both cases and was not reestablished.

No effect was produced by stimulation of the surfaces of the optic lobes with a current of sufficient strength to produce retardation if applied to the medulla. With a stronger current it was found that areas at the anterior end of the optic lobes frequently did not give any response, while those at the posterior end responded by a slight retardation of respiration. In general, the region from anterior to posterior was progressively responsive. This effect may have been largely due to the spread of current, for light mechanical stimulation with the blunt end of a match did not give a marked effect. When the tectum mesencephalici was removed, it was found that mechanical stimulation of the floor of the midbrain produced less retardation than electrical stimulation. In this region, a weaker current was required to produce respiratory retardation than that required to produce a similar effect when applied to the surface of the optic lobes.

In some cases electrical stimulation at the posterior end of the optic lobes resulted in contractions of the bodily musculature as well as in a retardation of respiration. These severe motor effects, which occur after transection of the thalamus and the spinal cord also, seem to be due to stimulation of descending motor fibers, particularly those going to the region of the neck and trunk.

Cerebellum (chart 2).—During removal of the cerebellum, generally accomplished by snaring with a loop of silk thread, the movements of the mouth as contrasted with those of the arches of the gills were especially spasmodic and irregular. Their amplitude was considerably reduced following the operation in three cases in which section of the four posterior roots of the vagus had been made previously. The respiratory rate did not appear to be affected.

Electrical or mechanical stimulation of the surface of the cerebellum does not affect the respiratory movements.

Medulla Oblongata.—Transections of the medulla oblongata at either the anterior or the posterior border resulted in a decrease in both the rate and the amplitude of respiration. The nearer the transection to the roots of the fifth, seventh, ninth and tenth cranial nerves, the more respiration is interfered with. It ceases entirely when a complete transection is made in this region.

In eight cases the medulla oblongata was sectioned sagittally without producing any effect on respiration. Transections were then made both at the anterior and at the posterior ends. Respiration continued, but with a lower rate and a greatly decreased amplitude.

TRANSECTION OF THE SPINAL CORD

A decrease in both the rate and the amplitude of respiratory movements, particularly those of the mouth, appears to follow transection of the spinal cord at its junction with the medulla (chart 3). In some cases there was a considerable muscular disturbance which obscured the respiratory record. The respiratory rate usually returns to normal within at the most two hours after the operation, while the amplitude may or may not reach its former level.

Transection of the spinal cord following section of both vagi in three instances resulted in total cessation of respiration.

In the dogfish, section of the spinal cord at the base of the medulla does not interfere materially with swimming. The ceaseless swaying movement which follows transection of both the spinal cord and the brain at the posterior end of the optic lobes is an interesting phenomenon. That constant stimulation may be the cause of this motion seems to be a possible interpretation (Bethe,[29] Van Rynberk [30]).

TRANSECTION OF DORSAL ROOTS OF THE SPINAL CORD

The following technic was used in sectioning the dorsal roots:

By means of a sharp razor a long cut was made through the skin along both sides of the fish at least ½ inch (1.27 cm.) above the lateral line, and extending to the caudal fin. A third incision joined these two longitudinal incisions at the region of the medulla. A flap of skin was then loosened, and with a sharp scalpel the muscles of the dorsal ridge were removed in the area blocked out. The spinal column was then laid bare. If this operation is done carefully and slowly, using magnesium sulphate as a local anesthetic in removing the skin, the fish makes little disturbance. The cartilage of the spinal column was then shaved down until only a thin layer remained over the cord. In *Squalus* the cartilage is so hyaline that the dorsal roots can be cut through the thin cartilage layer, thus avoiding considerable hemorrhage. In *Mustelus* the cartilage is more fibrous, making it necessary to bare the cord before sectioning the roots.

Chart 1 shows that a decrease in both the rate and the amplitude usually follows bilateral section of the dorsal roots. The rate returns to normal within at the most two hours after the operation, while the amplitude was not found to be entirely restored to normal. In *Mustelus,* probably due to the greater amount of trauma, the results of section of the dorsal roots are more severe than in *Squalus.* The fishes usually lived for from three to seven hours after the operation.

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29. Bethe, A.: Die Locomotion des Haifishes (Scyllium) und ihre Beziehungen zu den einzelnen Gehirntheilen und zum Labyrinth, Arch. f. d. ges. Physiol. **76**:470, 1899.

30. Van Rynberk, G.: Sur quelques phénomènes spéciaux de mouvement et d'inhibition chez le requin Scyllium, Arch. ital. de biol. **45**:58, 1906; Recherches sur la respiration des poissons, ibid. **65**:183, 1906.

In two experiments, section of the ventral roots and removal of the cord after section of all the dorsal roots did not cause further decrease in either the rate or the amplitude of respiration. In three instances, however, in which the spinal cord was transected after the dorsal roots had been cut as far caudally as the pectoral fins, a further decrease in rate occurred.

In four experiments, section of the dorsal roots was followed by transection at the posterior end of the optic lobes. Respiration ceased at once and did not become reestablished.

In two experiments, the dorsal and the ventral roots were cut, first on one side and then on the other. The results noted were the same as those which followed section of the dorsal roots alone.

Playing a stream of water over the bared spinal cord was found to retard respiration and make it irregular. This effect suggests that the retardation of the respiratory rate, following section of the dorsal roots, may have been due to stimulation of the cord produced by the slight tearing which even careful cutting of the roots at the cord might possibly involve. Modern theories of the "all or none" character of the nerve impulse, however, lend no support to this view.

Within a short time after death, the characteristic gray color of the dogfish begins to fade and is gradually lost.

COMMENT

Although the work of Rosenthal,[31] Hering,[32] Macdonald and Reid [33] and Winterstein [34] would seem to indicate that respiratory movements may occur independently of afferent impulses, the fact must be emphasized that in none of their experiments was the possibility of stimuli reaching the center along afferent nerves entirely precluded. Stewart and Pike [35] showed that the central cells of the respiratory mechanism are capable of sending out rhythmic discharges at a time when electrical

31. Rosenthal and Marckwald: The Movements of Respiration, translated by Haig, London, 1888.

32. Hering, H. E.: Ueber die nach Durchschneidung der hinteren Wurzetn auftiefenden Bewegungsbösigkeit des Rückenmark des Frosches, Arch. f. d. ges. Physiol. **54**:614, 1893.

33. MacDonald, J. S., and Reid, E. W.: Electromotive Changes in the Phrenic Nerve: A Method of Investigating the Action of the Respiratory Center, J. Physiol. **23**:100, 1899.

34. Winterstein, H.: Die automatische Tätigkeit des Atemzentren, Arch. f. d. ges. Physiol. **138**:159, 1911.

35. Stewart, G. N.: Some Observations on the Behavior of the Automatic Respiratory and Cardiac Mechanisms, Am. J. Physiol. **20**:407, 1907. Stewart, G. N., and Pike, F. H.: Resuscitation of the Respiratory and Other Bulbar Nervous Mechanisms with Special Reference to the Question of Their Automaticity, Am. J. Physiol. **19**:328, 1907; Further Observations on the Resuscitation of the Respiratory Nervous Mechanism, ibid. **20**:61, 1907-1908.

stimulation of the central end of the vagus or of the brachial plexus does not produce any change in the respiratory movements. These experiments must be regarded as affording the strongest argument for the automaticity of the central respiratory mechanism. Under no circumstances, however, are the respiratory movements normal in either form or rate after elimination of the afferent impulses. Complete automaticity of the respiratory mechanism is, therefore, an unusual and generally biologically inadequate activity. In an extensive series of researches on the respiratory mechanism of the cat, Pike and Coombs [36] found that a summation of both chemical and nervous stimuli, particularly afferent stimuli from the vagus and the dorsal roots, is necessary for the normal functioning of the sensitive cells of the "center" which must include the posterior part of the midbrain as well as the medulla oblongata.

Summary of Most Significant Experiments Showing Effect of Operations on the Respiratory Rate

Operation	Number of Experiments	Number Showing			Predominant Change	Percentage of Animals Showing		
		Increase	Decrease	No Change		Increase	Decrease	No Change
Cerebral hemispheres	20	8	3	9	No change	40	15	45
Thalamus	37	18	7	12	Increase	49	19	32
Cerebellum	15	5	4	6	No change	33	27	40
Spinal cord	11	1	7	3	Decrease	9	64	27
Optic lobes								
Median	10	0	6	4	Decrease	0	60	40
Posterior	27	3	20	4	Decrease	10	75	15
Mx 5								
Unilateral	8	0	5	3	Decrease	0	63	37
Bilateral	6	0	4	2	Decrease	0	67	33
Vagus								
Unilateral	17	1	12	4	Decrease	6	71	23
Bilateral	7	0	6	1	Decrease	0	86	14
Dorsal roots								
Unilateral	11	2	9	0	Decrease	18	82	0
Bilateral	11	1	10	0	Decrease	9	91	0

The experiments described in this article were undertaken in the effort to determine whether the respiratory mechanism of fishes is essentially the same as that of mammals. It was found that various alterations of the respiratory movements appeared to result from complete or partial transection of the brain at different levels. The most severe effects consistent with the maintenance of rhythmic respiratory movements followed complete transection at the anterior or posterior parts of the medulla oblongata. Transection of the medulla oblongata near the origin of the seventh, ninth and tenth cranial nerves caused permanent cessation of respiration. This fact may be explained, in part at least, by the location here of the central end stations of the

36. Pike, F. H.: Remarks on von Monakow's "Die Lokalisation im Grosshirn," J. Comp. Neurol. **29**:485, 1918. Pike, F. H., and Coombs, H.: The Organization of the Nervous Mechanism of Respiration, Science **56**:691, 1922.

nerves most intimately concerned in respiratory movements. In this region, therefore, is located the main motor "center." Since sagittal section of the medulla oblongata in the medial line does not have a serious effect on respiration, it may be concluded that in dogfishes, as in mammals, the respiratory "center" is bilateral.

In fishes, as in mammals, the "center" appears to be able to execute normal rhythmic and coordinated movements only when there is a summation of both chemical and nervous stimuli entering it. When a nerve such as the vagus or the maxillary branch of the fifth cranial nerve is cut, it seems to take longer for the dissolved substances in the blood to reach the level necessary for calling forth a normal respiratory response. The rate and amplitude of respiration consequently become decreased. Four factors must be considered here: the temperature; the volume of blood flow through the medulla oblongata in unit time; afferent stimuli coming in from the body, gills and regions of the mouth, and the concentrations of gases in the blood. In all the experiments the temperature remained nearly constant during the period of observation. The question as to variations in the volume of blood flow cannot be answered without more experimental data, since, apart from the observations made by Schoenlein and Willem, little is known of the effects of hemorrhage on the respiratory movements of fishes. The general consistency of the observations in the experiments described, however, makes it seem probable that the amount of hemorrhage did not reduce the volume of blood sufficiently to affect the conclusions reached.

That afferent stimuli are constantly coming into the respiratory center is shown by the effect of their sudden removal on the rate and amplitude of the respiratory movements. Through the maxillary branch of the fifth cranial nerve, and from the vagus, afferent impulses enter the center from the region of the nose and mouth as well as from that of the gills. Likewise, stimuli from the region of the trunk are constantly entering the respiratory center through the dorsal roots and the spinal cord.

The cutting off of these impulses causes a decrease in both rate and amplitude. This decrease in the rate and amplitude of the respiratory movements may be a nervous or a metabolic effect. If the effect is metabolic, it might be explained by a decrease in the production of carbon dioxide due to lessened muscular activity. But the fact that the rate, and usually the amplitude, tends to become restored after a time, and that this restoration, in the case of the dorsal roots, does not seem to be hindered by transection of the ventral roots and complete removal of the cord supports the view that a nervous rather than a chemical factor is here involved. It appears probable, therefore, that the restoration of rate and amplitude which occurs is due to the taking over of the old burden of control by the remaining afferent nerves.

Evidence in favor of this explanation is also given by the fact that transection at the caudal border of the optic lobes following section of the dorsal roots in all cases observed (four) caused a permanent cessation of respiration, presumably because of the further elimination of afferent stimuli, especially over the fifth nerve.

That there is in fishes, however, only a beginning of the relation of the afferent impulses from the muscles of the trunk to the respiratory mechanism is shown by the fact that the effects of section of the dorsal roots are not so severe as in mammals.

Section of the spinal cord at the medulla did not have so pronounced an effect on respiration as did section of the dorsal roots, possibly because the spinal cord in fishes functions more nearly as a segmental structure than it does in mammals or because of the greater trauma involved in the latter operation. At any rate, the dorsal funiculi have not yet appeared in fishes. When the spinal cord is cut, therefore, those afferent impulses which travel to the medulla oblongata by way of the cerebellar tracts are almost the only ones eliminated. When the dorsal roots are cut, not only is there a reduction in the amount of afferent stimulation entering the "center" but the carbon dioxide production in the musculature of the body must likewise be decreased.

The greater effects on respiration which follow successive transections made posteriorly through the midbrain show that the respiratory nervous connections most intimately concerned here are probably made at or near the caudal border of the midbrain. Possibly these connections involve afferent stimuli, since section at the posterior end of the optic lobes has, in general, about the same sort of effect as has section of the dorsal roots. It is significant to note in this connection that Allen [37] concluded that the radix mesencephalica trigemini in the guinea-pig is associated with the muscle sense. This may furnish an affirmative answer to the question as to whether the midbrain in vertebrates has always been involved in the normal functioning of the respiratory mechanism. It is probable, therefore, that the central mechanism of respiration in fishes includes the caudal part of the optic lobes as well as the medulla. In fishes the results of lesions at the posterior end of the optic lobes are, however, less marked than corresponding lesions in mammals.

The fact that compensation occurs after transection of certain parts of the nervous system in fishes does not necessarily indicate that the eliminated structure or region plays a relatively unimportant part in maintaining normal respiratory movements. If this is true, it ought to be possible to eliminate not only one source of stimulation, or one central mechanism, but two or three without any serious effect. For

37. Allen, W. F.: Application of the Marchi Method to the Study of the Radix Mesencephalica Trigemini in the Guinea-Pig, J. Comp. Neurol. **30**:169, 1919.

instance, it should be possible to make a transection at the posterior end of the optic lobes and to cut the dorsal roots of the spinal cord without affecting the respiratory mechanism. It was found, however, that while it is possible to sever the central connections of one of these mechanisms without permanent effects, survival for any considerable time seems to be impossible if both sources of stimulation are eliminated in the same animal. Likewise, transection at the posterior end of the optic lobes and section of the vagi have a more drastic effect on the respiratory mechanism than transection of either alone.

It is not possible at present to state in which tracts of the central nervous system these afferent stimuli travel. In mammals a group of fibers of the ventrolateral and dorsal cerebellar tracts go to the midbrain without entering the cerebellum. The course of these fibers was traced by Bruce [38] in the monkey. Since the tract is extremely old phylogenetically, it might be expected to be present in fishes. As a matter of fact, the cerebellar tracts in this group are the great afferent channels to the cerebellum. To what extent the nerves of the head might be related to the tract described by Bruce is hazardous of conjecture. In the monkey the tract is purely somatic, with no facial or visceral components. The known midbrain connections of the fifth cranial nerve, and the effects of section of the maxillary branch, may possibly be taken as an indication that the respiratory relationship is established through the midbrain in fishes. Some descending connection between the medulla oblongata and the midbrain might be assumed through the formatio reticularis of the midbrain and the hindbrain. It seems clear, from the great importance of the fifth cranial nerve as a motor nerve for the muscles of the mouth, that there must be in the reticular formation some fibers ascending from the region of the vagus nucleus or other cells in the medulla oblongata, constituting the motor group for respiratory movements, to the fifth nerve. Since this reticular formation has never been analyzed, however, it is impossible to venture further in attempting to trace an anatomic connection.

In mammals there is a great variety of connections of these fibers of the fifth anterior to the midbrain. More specialized and finer responses are the result. Since the roof of the cerebral hemispheres in fishes is primitive, such responses are not present. That there are, however, nerve connections, possibly in the basal forebrain ganglia, which can affect the normal functioning of the respiratory mechanism is shown by disturbance of the respiratory rhythm during transection of this region of the brain. Since no after-effects on respiration are apparent following such transection, however, it seems probable that the nervous elements here located play only a minor part in the mechanism

38. Bruce, A. N.: The Tract of Gowers, Quart. J. Exper. Physiol. **3**:391, 1910.

as a whole. The respiratory muscles, particularly those of the mouth, are used in other movements, such as seizing food, and for these activities may be under the control of some group of nerve cells remote from the central cells of the respiratory mechanism in the medulla. Transection of the cerebral hemispheres, or of the thalamus, might cut across descending fibers concerned with these extrarespiratory movements. The disturbances in respiration might thus be only incidental to the other movements set up by the stimulation of these nerves in the transection. According to Herrick, the thalamus and the hypothalamus are old phylogenetically; if so, it is not surprising that they should be involved in a life process so fundamental as seizing food.

In the transition from fishes to mammals the burden of the afferent function in respiration seems to have shifted from the fifth and tenth cranial nerves to the general somatic nerves. Sufficient anatomic evidence of a change in the central connections of the fifth cranial nerve is not available to justify the prediction that it would have no important relation to respiratory rhythm in mammals, as contrasted with its relation to these movements in fishes. As a matter of fact, both the afferent and the efferent relations of the fifth nerve to respiratory movements persist in mammals, but become apparent only in specialized muscles or under special conditions. The dropping out of the primitive respiratory importance of the fifth nerve in this group seems to be determined more by use and disuse than by any profound underlying changes in its central connections in the medulla, pons and midbrain. The emphasis has shifted to the afferent fibers from the thoracic muscles and the diaphragm.

The seventh cranial nerve in fishes is predominantly motor in its effect on respiratory movements. In mammals under ordinary circumstances, this nerve is passive in respiration. In dogfishes it is not easily possible to differentiate the effect on respiration of section of the fifth and the seventh cranial nerves. The nuclei of the fifth nerve are situated near the posterior border of the optic lobes, and the connections of the seventh nerve are tied up with them. After section of the brain in this region, therefore, one would expect to find a decrease in the amplitude, not only of the movements of the mouth but also of the first and second arches of the gills. But the movements of these arches are so closely related to those innervated by the ninth and the tenth nerves that it has not been possible, thus far, to determine whether this condition is realized.

The ninth nerve in fishes is likewise largely motor in its relation to the respiratory mechanism. In mammals the mere contact of fluid with the sensory endings of the ninth nerve is sufficient to excite swallowing movements. The source of afferent stimuli involved in the swallowing mechanism in fishes is unknown, but it is certain that con-

tact of the water with the surface of the respiratory membranes is insufficient to bring this mechanism into play. In experimenting with various concentrations of strychnine sulphate on *Fundulus*, it was evident that water was not ordinarily swallowed during respiration. This fact is an interesting example of adaptation. It is difficult to conceive of the survival of fishes in which the swallowing and the respiratory nervous mechanisms were not separate.

The vagus plays the part of both a sensory and a motor nerve in the respiratory movements of fishes. It innervates muscles intimately concerned in these movements. In mammals, on the contrary, the striated musculature thus innervated comprises only that of the larynx, the upper part of the esophagus, and possibly the lower part of the pharynx.

When section of the vagus on one side brings about a decrease in the rate and amplitude of respiration, transection of the other vagus may have little added effect. The converse is also true. It appears, therefore, that the vagi play a rather definite part in the control of the respiratory mechanism. The different physiologic condition of the fishes used in the experiments may be a factor in this result also. In the more vigorous fishes one vagus may be able to supply sufficient afferent stimulation to maintain the tonus of the muscles of the mouth.

The nervous organization of the respiratory mechanism in fishes may be summarized as:

1. A central motor mechanism, located in the medulla oblongata.

2. The afferent nerves: (*a*) Afferent nerve trunks of the cranial nerves, chiefly the maxillary branch of the fifth nerve, and the vagus. The spinal nerves must probably be included also. (*b*) The central end-stations of the afferent nerves. The vagus nerve seems to have maintained a relatively constant position throughout the phylum. Its central end-station lies in the medulla. The central nerve connections of the fifth nerve with one central end-station in the midbrain appear to have shifted in functional importance in the evolutionary process, as has also the importance of the spinal nerves.

3. The efferent nerves: The efferent path is through the fifth, seventh, ninth and tenth cranial nerves. There must be some descending pathway to the respiratory motor nucleus in the medulla oblongata from the fifth cranial nerve. This descending path persists in mammals. There is no indication of a descending tract from the central motor mechanism in the medulla oblongata to the ventral horn cells of the spinal cord, nor would one be expected.

4. The dependence of motor response on afferent impulses and the central end-stations through which this afferent influence is exerted.

These stations include the posterior part of the corpora bigemina (optic lobes) and the medulla oblongata. The general functional relations of afferent to efferent roots (Sherrington[21]) are exemplified in the respiratory response as in other motor responses of striated muscle. A summation of stimuli from the roots of afferent nerve and from the gases dissolved in the blood occurs in the central motor cells of the respiratory mechanism.

SUMMARY

Normal inspiration in selachians consists in the opening of the mouth and the rushing of water into the buccal and pharyngeal chambers which are enlarged by the bending of the arches of the gills. The gill clefts remain closed. In expiration the mouth is closed, and water is forced through the gill clefts.

While temporarily the respiratory rate varies directly with the pressure of the respiratory current, there is for individual fishes an equilibrium point to which the rate returns after a period of time whether the current is weak or strong. The variation in rate differs in degree with the size, age and physiologic condition of the animal. It is a reflex the afferent channel of which, in part at least, seems to be through the vagus nerve.

Extensive capillary hemorrhage, especially in the fins, may be induced by rapid changes in the strength of the respiratory current under experimental conditions. Section of the vagi, in some instances at least, appears to diminish the amount of such hemorrhage.

Stimulation of the head and lateral line regions by pressure or by electric current, either on the outer surface of the body or with the skin removed, follows du Bois-Reymond's law. When mechanical or electrical stimuli are applied directly to the dorsal musculature of the body, or to the adductor muscle of the mandible, the respiratory movements become irregular, and the rate may decrease slightly.

The musculature involved in the respiratory movements in teleosts responds to treatment with strychnine sulphate or to caffeine as do the somatic muscles of mammals. Caffeine is absorbed through the mucous membranes of the mouth and gills in sufficiently large quantities to prove toxic, but strychnine sulphate is not.

In teleosts contact of the water with the surface of the respiratory membranes is not an adequate stimulus to bring the swallowing mechanism into play.

Transections of the olfactory tract and of the seventh and ninth cranial nerves, when the other cranial nerves are intact, have no effect on the respiratory movements. Electrical or mechanical stimulation of the central end of the olfactory tract has no effect on respiration. Such stimulation in the case of the seventh and ninth cranial nerves results in a slight retardation of the respiratory rate.

Ether, chloroform and chloral have no specific respiratory effect when applied to the olfactory capsules. Slight pressure in the application of these substances, or in the removal of water from the olfactory capsules, results in respiratory irregularity, a decrease in rate and reversal of the respiratory current. The afferent channel for this response seems to be not through the olfactory tract but through the fifth cranial nerve.

Unilateral section of the maxillary branch of the fifth cranial nerve in the orbit may result, and bilateral section usually results, in a temporary decrease in the amplitude of the respiratory movements, especially those of the mouth, and a temporary decrease in rate which is usually preceded by a reversal of the respiratory current.

Unilateral section of the vagi usually results, and bilateral section does result, in a decrease in the rate and amplitude of respiration.

Mechanical or electrical stimulation of the central end of the maxillary branch of the fifth cranial nerve, or of the vagus, has a similar but more transitory effect on respiration than has section of these nerves.

Transection and stimulation of the cerebral hemispheres, or their removal, results only in irregularity of the respiratory movements. Swimming appears to be normal after their removal.

Transection of the thalamus results in irregularity of respiration which may or may not be followed by an acceleration of the rate. Electrical stimulation of the floor of the thalamus has the same effect as transection.

Transection of the optic lobes appears to have a progressively greater effect the more caudal the lesion. Transection of the anterior third produces great irregularity of the respiratory movements, particularly those of the mouth. The rate is not affected significantly. Transection at the caudal border of the optic lobes usually produces a marked decrease in both the rate and the amplitude of respiration. In some cases there may be a cessation of respiration for several seconds after transection. The rate is restored to its former level soon after transection. In some cases, the amplitude is also restored. After transection at the posterior end of the optic lobes, the fish exhibits a ceaseless swaying motion of the caudal parts of the body. Sagittal section of the optic lobes has no effect on respiration.

Removal of the cerebellum (corpus centrale) produces irregularity of the respiratory movements, particularly those of the mouth. In some cases the amplitude of the movements of the mouth is reduced for several minutes following the operation, but the rate is unaffected.

Electrical or mechanical stimulation of the surface of the cerebellum has no effect on respiration.

Transection of the medulla at either the anterior or the posterior border results in a decrease in both the rate and the amplitude of the respiratory movements. The results of transection of different regions of the medulla indicate that the chief motor center of the respiratory mechanism is located in the region of the seventh, ninth and tenth nerve nuclei. This center is bilateral.

Section of the spinal cord at its junction with the medulla usually results in a decrease in both the rate and the amplitude of respiration.

Section of the dorsal roots of the spinal cord has a similar effect, but usually a more drastic one. As a rule, the rate is restored to that before section of the roots, while the amplitude is not observed to return to its former extent.

Transection of the ventral roots and removal of the cord following section of the dorsal roots do not cause a further decrease in amplitude or rate.

RELATION OF INFANTILE CONVULSIONS, HEAD-BANGING AND BREATH-HOLDING TO FAINTING AND HEADACHES (MIGRAINE?) IN THE PARENTS*

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For several years we have been especially interested in the symptomatology of epilepsy [1] and the relation of this disorder to other symptoms and derangements referred to the central nervous system. Our study began with an analysis of the records of 1,000 epileptic patients seen in private practice.

In a previous paper we presented a study of the relative frequency and significance of infantile convulsions in epileptic patients and in unselected groups. The composition of these groups on the basis of industrial classification and their statistical validity were also considered.[2] It was shown that the incidence of infantile convulsions is significantly greater in epileptic children than in unselected children; that infantile convulsions are more frequent in the families of children with infantile convulsions than in the families of those without; also that the probability of later epilepsy is greater for children who have infantile convulsions.

Later, studies were made of similar unselected groups for the collection of data on certain "explosive" phenomena in children and on periodic headache and fainting in adults, especially parents. The "explosive" phenomena selected were infantile convulsions, breath-holding, head-banging and a miscellaneous group of periodic attacks, chiefly vomiting spells. This selection was suggested by our clinical experience with the 1,000 epileptic patients previously cited and with children examined at the mental hygiene clinic of the Michael Reese Dispensary and at "Baby Shows." This experience led to the inference that such symptoms were especially common in the relatives of epileptic persons and of infants with eclampsia.

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1. Patrick, H. T., and Levy, D. M.: The Diagnosis of Epilepsy, J. A. M. A. **79**:1009 (Sept. 23) 1922.

2. Patrick, H. T., and Levy, D. M.: Early Convulsions in Epileptics and in Others, J. A. M. A. **82**:375 (Feb. 2) 1924.

Periodic headache (migraine) has long been considered to be related in some way to epilepsy because of certain similarities [3] in the symptomatology, because the headaches sometimes alternate with, are supplanted by or supplant true epileptic seizures, because a migraine aura may become an epileptic aura in the same patient, and because of the frequency of periodic headache in the families of epileptics.[4] Recently, a close hereditary relationship has been predicated, migraine being to epilepsy as a recessive to a dominant character in true mendelian heredity.[5] Since such studies, to justify reasonable conclusions, require data on the incidence of migraine in unselected groups, a census of this type was made of the parents of five groups of unselected children. In addition, data were secured on fainting in the parents of the children studied in two communities.

This paper is limited to a study of the frequency and relationship of the symptoms indicated in the title. Since validity of conclusions depends first on accuracy in collecting the data, it is advisable to describe our method.

METHOD OF STUDY

The informants were chiefly the mothers of children attending Better Baby Conferences in small communities. The towns and their populations were: Sparta, 3,340; Mendota, 3,934; Aledo, 2,231; Watseka, 2,817; Peoria, 76,121. In Mendota and Aledo the questions were asked in the last examining booth (for examination of the genitalia). The advantage lay in the fact that the child's examination card was completed in this booth and mothers would not suspect that their replies might influence the child's score. The disadvantage lay in the mother's fatigue after she had hurriedly carried the child from one physician to another for about half an hour. The cards were returned to the mother, questions answered, and then the mother was told that if she wished she might answer certain medical questions for the doctor which had nothing to do with the scores. In one community (Peoria) the questions were asked in the dressing room after the child's examination was completed; in Sparta and Watseka such questions were asked immediately after the mental testing, the first phase of the examination. No offense was taken at any question asked; cooperation was satisfactory in every case.

Only such headaches were recorded as periodic that satisfied the criteria of (1) periodicity, (2) similarity, (3) self-limitation in time (from one-half hour to several days) and (4) chronicity (duration in every case greater than five years).

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3. Gowers: The Borderland of Epilepsy, Philadelphia, P. Blakiston's Son & Co., 1907, chapter 5.

4. Footnote 3. Redlich: Zum Kapitel Migräne und Epilepsie, Wien. klin. Wchnschr. **39**:21 (Jan.) 1921. Liveing, Edward: Megrim, Sick Headache and Some Allied Disorders, London, J. & A. Churchill, 1873.

5. Buchanan: A Study of the Hereditary Factors of Epilepsy, Minnesota Med. **3**:526 (Nov.) 1926; Familial Distribution of the Migraine-Epilepsy Syndrome, New York M. J. **113**:45 (Jan.) 1921; Mendelianism of Migraine, M. Rec. **98**:807 (Nov.) 1920.

Such criteria have been accepted for office work and are, in the main, criteria for migraine headaches in studies by others. Generally, severity has been assumed to be one of the criteria of migraine—an assumption which we are strongly inclined to believe is unwarranted. Definite questions were asked about accompanying nausea, vomiting, dizziness and various forms of visual disturbance in all but one community (Watseka). There, no questions were asked about accompanying symptoms, and such were recorded only when spontaneously contributed in answer to the question "what kind of headache do you have?" It is in this (Watseka) group, therefore, that the percentage of headaches without further classification runs so high. In the group labeled "headache without foregoing symptoms" sometimes by-symptoms were reported such as "heavy feeling," "nervousness," etc. These symptoms were not classified.

Considerable experience with this type of interview indicates that the percentage of headaches recorded is a low estimate. In some cases, for example, typical and severe migraine occurred with throbbing hemicrania, vomiting and relief through sleep, the entire duration being about twelve hours; the frequency, however, was but once or twice a year. Headaches so rare are apt to be considered by the patient as due to casual indiscretion and not worth talking about; such answers as "hardly ever," or "if I have I don't remember them," are often received. Further questioning is necessary to uncover this real migraine. If the patient is seen months after such a headache it may be forgotten; so also with respect to accompanying symptoms. When vomiting occurs, headaches, though infrequent, are more likely to be remembered than if slight nausea or slight dizziness alone accompanies the ache. Furthermore, there is a disposition on the part of some people to deny the existence of such symptoms, except in the doctor's office, especially if they have never received medical treatment for them. Often such denials are part of the statement that "I have never had an ache or a pain," "I've never been to a doctor in all my life," and belong to a general attitude that cannot be sufficiently challenged in the short time allowed for rapid interviewing. Many persons also regard mild and even moderately severe recurring headache as a natural phenomenon (just as many women regard menstrual cramps as normal) and do not consider it to be a real headache. They may respond to the question "Do you ever have headaches, even very little ones, or very mild ones?", with "Oh, yes, I have headaches but they don't amount to anything"; on closer questioning these may be found to be typical migraine by the criteria cited.

There enters here also the notorious tendency of the patient to confuse the manifestation with the assumed etiology. Such headaches are often thought of as indigestion, constipation, "auto-intoxication," "biliousness," eye-strain, etc., and consequently would not be spontaneously reported as "headache."

These and other considerations indicate that the incidence of headaches recorded in this paper is low. The incidence of severe headaches with more objective concomitants (vomiting, necessity of going to bed in the daytime, scotoma) is more likely accurate. It was our general impression that the vast majority of women have periodic headaches of varying severity.

In computing the frequency of headache and fainting, data of women only have been used, since their knowledge of the husband's symptoms is so limited. When such information was given it was utilized in correlating the symptoms in the parents with the symptoms of convulsions, head-banging and breath-holding in the children.

FREQUENCY OF PERIODIC HEADACHES

In table 1 the Watseka list is of special interest because the classification was determined by the spontaneous replies of the patient to the general question concerning periodic headache rather than by answers to specific questions as used in compiling the other lists. As compared with the other communities, the number of headaches with dizziness is relatively larger, and there were none with nausea. The frequency of headache with vomiting and with visual symptoms is fairly similar in all towns. One would expect a relatively larger number of headaches without further classification in this group (Watseka) since specific questions were omitted. In all the groups in which a mixture of various symptoms occurred, the classification is based on the most prominent symptom. For example, in case of headache with nausea, vomiting,

TABLE 1.—*Frequency of Periodic Headaches in Unselected Groups*

	Community									
	Sparta 1922		Peoria 1923		Mendota 1925		Aledo 1925		Watseka* 1922	
Total number of cases (women)..	87		102		80		102		181	
	No.	%	No.	%	No.	%	No.	%	No.	%
Periodic headache with nausea and vomiting	7	16.3	6	23.1	7	23.3	15	46.9	10	9.9
Periodic headache with nausea only	11	25.6	4	15.4	8	26.7	1	3.1	0	0.0
Periodic headache with dizziness	9	20.9	6	23.1	6	20.0	8	25.0	29	28.7
Periodic headache with visual symptoms	0	0.0	2	7.7	2	6.7	3	9.4	3	3.0
Periodic headache without foregoing symptoms	16	37.2	8	30.7	7	23.3	5	15.6	59	58.4*
Total headaches	43		26		30		32		101	
Percentage of total headaches..		50		26		38		32		56

For the entire group of 552 women, total number of cases of periodic headache, 232 (42%)

* For Watseka a different method of securing data was used as noted in the text.

dizziness and scotomas, classification, for convenience, is by the symptom regarded by the patient as the most severe. Headaches are classified as "with nausea and vomiting" even when vomiting occurs seldom though nausea is frequent. The term dizziness is vague and often confused with nausea. That the highest percentage of headaches was secured in Sparta and Watseka, where interviews took place at the beginning of the child's examination, is interesting. In the other communities the interviews were held in the last booth after the mothers had spent about half an hour carrying the child to the various physicians. Probably they were much less receptive to questions at this time.

It will be seen, therefore, that many influencing factors make an accurate estimate of the incidence of periodic headache in the general population difficult. These have to do chiefly with the cooperation and intelligence of those interviewed and the severity, frequency and definiteness of the symptoms investigated, as well as the amount of time

and skill at the disposal of the interviewer. From the tables one is led to infer that mothers were more receptive to questions of this character at the beginning than at the end of the long examination. However, since not one refused to answer the questions, one may conclude that frequent or severe headaches would more likely be spoken of than mild or rare headaches. This should be true also of headaches with, as contrasted to those without, accompanying symptoms. "Just headache," if infrequent, is less likely to be remembered than headache of no greater severity but accompanied by vomiting, or "blind spots," or dizziness. Likewise, any headache, regardless of subjective considerations of severity, is more likely to be remembered if one quits one's housework during the period of the headache than if one works on in spite of it. Hence, we believe that these statistics contain a fairly accurate representation of such periodic headaches as are frequent, severe and accompanied by relatively objective criteria, and present a rather low estimate of headaches that are mild, infrequent and unaccompanied by such symptoms as dizziness, vomiting and visual disorders.

Careful inquiry among one's friends will help greatly in understanding these difficulties and, incidentally, in realizing the remarkable frequency of periodic headache. A physician, aged 40, who looked over table 1, asked how one could be sure of such data, whereon the same set of questions was asked of him. His headaches occurred as frequently as once in two weeks, as infrequently as once in two months; they usually lasted until relieved by 10 grains (0.65 Gm.) acetylsalicylic acid; incapacity was of about one hour's duration. There were no accompanying symptoms of the types enumerated. The condition was described simply as a throbbing ache of the entire head; the onset was in early childhood, and the family history was positive. This type of headache is easily discounted by the patient, often denied or forgotten, and it therefore varies greatly in statistical frequencies.

Besides the factors enumerated there are also to be considered actual variations in the frequency of headaches in different unselected groups, due to racial and other factors besides chance statistical variations. In the communities studied the one city group (Peoria) had the lowest frequency. Further studies are necessary to cover these points.

Determination of the severity or intensity of the headache is difficult. Headaches are described as "violent," "throbbing," "sharp," "like a toothache," "pressure," "fulness," "dulness," etc. The description of the ache was not used for purposes of this classification because of the vagueness of these terms and the marked variation in subjective reactions to the same sensation. A more objective criterion of severity would be the amount of incapacity in terms of time taken out of work, though this again would vary with personality differences and facilities

for leisure. Since most of the women studied were farmers' wives who do their own housework, such a classification may have an actual relation to severity.

In Sparta, such a classification was made. Headaches were considered mild when the patient went through the day's work in spite of them; moderate if the time taken out was from one half to two hours; severe if the time taken out was more than two hours. Headaches with vomiting were included in the group of "severe" headaches. On this basis, only ten of the forty-three cases of periodic headache in eighty-seven women of this community may be considered as severe. Omitting the headaches with vomiting, only three of the remaining thirty-six cases can be so considered.

The concept of migraine has changed greatly in recent years. Some neurologists still adhere to the precise formulation of Tissot (1813):

TABLE 2.—*Periodic Headaches (Sparta) Classified on the Basis of Time Taken Out of Work*

Total number of women interviewed	87
Total cases of headache	43

Number of Cases of	Mild	Moderate	Severe
1. Periodic headache with vomiting	—	—	7*
2. Periodic headache with nausea	8	2	1
3. Periodic headache with dizziness†	3	4	2
4. Periodic headache with visual symptoms	0	0	0
5. Periodic headache without accompanying symptoms 1, 2 and 3	15	1	0
Total	23	7	10

* All headaches with vomiting were counted as severe, the time factor not being considered.
† Visual symptoms were given in two cases of headaches with dizziness and in one case of headaches with vomiting. The classification of headaches with accompanying symptoms was made according to the most severe symptoms.

a severe, periodic hemicrania, especially in the forehead, eyes and temple. Head (1898) would restrict the term to headaches having the following characteristics: (1) occurring among men engaged in intellectual pursuits; (2) beginning often with marked disturbances of vision, for example, scotoma, hemianopia or fortification figures; (3) followed by intensive more or less localized headache; (4) often ending with intensive vomiting. All the cardinal points enumerated have been abandoned except periodicity and probably intensity of the attack. Gowers,[2] for example, employs the term migraine for "paroxysmal headaches in general." Oppenheim states that "the most important and often the only symptom is a periodic attack of violent headache which is associated as a rule with gastric disturbance, loss of appetite, nausea, flatulence and vomiting." Neither Gowers nor Oppenheim indicates anything "cardinal" in the unilaterality nor in visual or other accompanying symptoms. The question of intensity remains. Oppenheim apparently demands that it be "violent," but Symonds observes that many headaches similar

to or supposedly migrainous are not intensive. Rostock's criteria (1922) are: (1) heredity, (2) periodicity with restitutio ad integrum and (3) paroxysmal headache with nausea and vomiting. In a recent report Crookshank defines migraine as "a peculiar and paroxysmal and therefore recurrent headache that is usually but not invariably referred to one side." [6]

Severity, based on the subjective sensation, may of itself be a selective factor in determining those particular patients who present themselves to the physician for treatment. If a patient has periodic headaches as "intense as a toothache," "throbbing and cutting," etc., he is more likely to seek treatment than if the headache, though of longer duration, is "dull" and can be tolerated. When visual symptoms occur, the ophthalmologist is often sought; when nausea and vomiting occur, the internist. In general, one may assume that patients seek medical aid for headaches because of (1) pain, (2) incapacity and (3) fright. That group of patients who seek medical aid because of pain would include especially those patients whose pain is intense, regardless of duration or accompanying symptoms. The group who seek medical aid owing to incapacity would include especially workers who would be prevented from working, aside from the question of intensity. The group who seek medical aid owing to fright would include not only the more timid and apprehensive patients but especially those who have dizzy attacks, temporary amblyopia, scintillating scotoma and the like, symptoms which are of themselves frightening because they are suggestive of serious disease. Least likely to seek medical aid would be patients with headaches of slight intensity, slight or no incapacity, and slight or no accompanying symptoms.

Our statistics lead us to infer that previous authors have based their conclusions on the observation exclusively, or almost exclusively, of severe samples of migraine and that therefore their statistics would include, especially, visual, gastric and other striking constituents. The milder cases are seen by family physicians as "abortive forms," as early forms not yet severe, as variations in patients with severe attacks (rare) and as attentuated forms in other members of the family and in children. In the last, especially, are seen headaches without accompanying symptoms as classified in our lists. Many cases of so-called cephalalgia belong in this group. Probably some cases of cyclic vomiting in children are to be considered as the equivalents of migraine.

For the purpose of this comparison a study of 100 cases of migraine taken seriatim from our private records has been made. Comparing early with late manifestations it is found that in the majority of these

6. Entire discussion may be found in Flatau, Edward: Die Migräne, Berlin, Julius Springer, 1912, chapter 1.

cases there had been an increase in frequency, duration or intensity of symptoms preceding the visit to the office. Few patients present themselves in the early years of migraine; most of ours came twenty or more years after the onset.

It will be noted (table 3) that the median age [7] of onset in this series is from 12 to 13 years; the median age at the time of first examination is about 36 years. In this group of 100 patients the duration had been longer than twenty years in the vast majority; during this period there

TABLE 3.—*Age at Onset and Age at First Visit to the Office in One Hundred Private Cases of Migraine*

Age	9 Years or Under	10-19 Years	20-29 Years	30-39 Years	40-49 Years	50-59 Years	60-69 Years
At onset, number of patients..	45	29	23	3	0	0	0
At office visit, number of patients	..	3	25	32	27	11	2

TABLE 4.—*Early and Late Frequency as Estimated by Patients in One Hundred Private Cases of Migraine*

	Headaches Once a Week or Oftener	Once in from 2 to 4 Weeks	Once in from 5 Weeks to 3 Months	Once in 4 Months or Less Frequent
Early frequency	16	44	21	13*
Late frequency	48	34	3	0*

* Stated as "increased severity and frequency" without further description of late frequency in ten cases. Frequency not stated in one case. Early frequency not stated; late frequency stated in four cases.

TABLE 5.—*Duration of Attacks as Estimated by the Patients in One Hundred Private Cases of Migraine* *

	Several Hours	Part of Day (6 to 12 Hrs.)	24 Hours	1 to 2 Days	2 to 3 Days	Longer Than 3 Days
Early duration....	25	38	9	5	10	0
Late duration	5	28	9	8	19	14

* Early and late duration not stated in six cases. Early duration not stated in seven cases. Stated as increased severity and frequency without estimating late duration in twelve cases.

had been in nearly all cases an increase in the severity, frequency and duration of the attacks (tables 4 and 5).

From this one might infer that the patients who consulted us because of migraine would not have done so in most cases if the attacks had not become progressively worse. That is equivalent to saying that if in these same patients the migrainous attacks had in time diminished, remained constant or disappeared they would not have come for treat-

7. Median is the midpoint of a series, i. e., the midfigure of the ages if ages were distributed from lowest to highest.

ment. Should conclusions about migraine be drawn solely from one's patients, therefore, one would be committing the fallacy of generalizing from cases selected because of continuing or increasing severity. These cases may, perhaps, present the type of migraine manifested in a small percentage of the migrainous. From our data on the "unselected" groups of women we might well be led to infer that our office cases actually represent but a small percentage of the total migrainous forms, the majority of which are milder manifestations of the same disorder. The problem involves a number of general statistical considerations and demands extensive medical investigation. Clinical research on migraine has been made chiefly by specialists—neurologists and internists. Judging by our private cases, these specialists have inevitably selected for study a type of migraine of special and increasing severity, or one complicated by elements other than pain. If clinical investigations had been made chiefly by the general practitioner, who is more likely to see

TABLE 6.—*Probable Immediate Reasons for Consultation in One Hundred Cases of Migraine*

	Number of Cases
1. Early migraine	7
2. Change in character of migraine:	
a. Increased intensity, duration or frequency or combinations of them	80
b. A new accompanying symptom or sequel	7*
3. Migraine with or secondary to other complaints	22
4. Migraine an incidental observation (included also under 2)	8

* Of these, two cases are also included under increased intensity group. They include the following symptoms: aphasia, ptosis, tingling or numbness in limb, "mental blankness."

incipient and mild cases and those with a more favorable course or termination, the estimate of the relative frequency of different forms might have been more accurate—a more comprehensive view of migraine.

Naturally, study of an unselected group, containing, as it does, numbers of people who never regarded their periodic headaches as of sufficient importance for medical aid, would show a higher percentage of mild forms.

In our private series, the reasons for the consultation may be gleaned from the anamnesis. When migraine is diagnosed along with other conditions, such as arthritis, it is sometimes difficult to determine whether the joint pain or the headaches are the primary complaint, or whether they are equally weighted. One feels reasonably certain of groups 1 and 4 in table 6: group 1, in which migraine is the sole complaint, and group 4, in which it is a purely incidental observation. In group 2, of the eighty-five patients included, one is certain that in sixty-three a change in the character of the migraine was the primary complaint, and that it was primary or at least an important reason for coming in the remaining twenty-two.

Further comparisons may be on the basis of accompanying symptoms, as is done in table 7 in the 100 private cases. In the grouping several symptoms for each case are included.

In comparing the unselected group with the private group (table 1 with table 7), allowance must be made for the fact that in table 1 classification is made on the basis of one most important accompanying symptom, whereas in table 7 all accompanying symptoms are included. A direct comparison may be made, however, since if table 1 were altered to conform with table 7 the change would largely be in the group with visual symptoms, which in the unselected group were chiefly spots and of primary importance in only a small percentage (from 0 to 3 per cent).

TABLE 7.—*Accompanying Symptoms in One Hundred Private Cases of Migraine*

	No. of Cases	Percentage
Nausea	14	10
Nausea and vomiting	59	42
Dizziness	91	8
Visual	25	17
No accompanying symptoms	17	12
Other symptoms (numbness, aphasia, screaming spells, depression, ptosis, tingling)	16	11

TABLE 8.—*Comparison of Periodic Headaches in Unselected and Private Groups*

Percentage of Headaches with	Patients in Towns of Mendota, Aledo and Peoria	One Hundred Private Cases
Nausea (not with vomiting)	14	10
Nausea and vomiting	34	42
Dizziness	20	8
Visual	8	17
No other accompanying symptoms	24	23

There is a similarity, as will be noted, in the two groups, especially in nausea and vomiting. Visual symptoms are relatively more, and dizziness relatively less, frequent in the private group. The frequency of vomiting, the most accurately determined symptom, is first in both groups. In general it may be said, in contrast with the private series, that usually one or at most two symptoms are complained of along with headache in the unselected group; also that in the unselected group "no other accompanying symptoms" did not include symptoms such as numbness, tingling, aphasia and ptosis. From these comparisons it appears that we are dealing with similar types of periodic headache though of different severity.

A family history of migraine was obtained in 81 per cent of the private cases; in a parent in 71 per cent (mother, 51 per cent; father, 20 per cent); in a brother, sister or other relative in 10 per cent.

Similarly, there is a high frequency of periodic headache in the family histories of the persons with headache in the unselected groups, varying from 55 to 80 per cent, average, 66 per cent.

We have shown, so far, through scrutiny of the criteria of migraine and a comparison of an unselected with a frankly migrainous group, that the periodic headache in the unselected groups probably belongs in the same category of disease. Hence, we believe that it is much more frequent than was previously realized, the type covered in the medical

TABLE 9.—*History of Periodic Headache in Families of Persons Who Had Headaches, in Unselected Groups* *

	Father, Percentage	Mother, Percentage	Others (Brothers, Sisters, Uncles, Aunts or Grandparents) Percentage	Total, Percentage	Unknown to Patient, Percentage
Watseka	6	43	6	55	13
Sparta	17	37	9	63	17
Mendota	8	67	5	80	9

* In the group of 100 patients, those whose family history was unknown were not included.

TABLE 10.—*Fainting as a Symptom with Assigned Cause in Fifty-One Cases* *

Assigned Cause	Fainted Once or Twice (21 Cases)	Fainted Three or More Times (30 Cases)
Pregnancy	2	11
Menstruation	1	0
Miscarriage	0	0
Childbirth	1	0
Pain	3	7
"After operation"	3	1
"During an illness" (smallpox, typhoid, influenza, urticaria)	1	4
"Dietary indiscretion" and indigestion	1	4
Heat	2	2
Close air	1	0
Fitted for dress	1	2
Sight of blood	0	2
Fright	2	0
Excitement	0	1
Grief	0	1
Fatigue	1	3
Dizziness	0	1
Probing ear for wax	0	1
No cause assigned	2	9

* All causes given are listed.

literature being one selected on the basis chiefly of severity or change in character.

Apparently, fainting has been accepted as so frequent and, hence, "natural" a phenomenon as to receive insufficient consideration in medical literature. Gowers'[2] differentiation of it from epilepsy seems to have been a final word on the subject.[8] As a single mishap, it is felt to be

8. Allbutt and Rolleston: A System of Medicine, New York, The Macmillan Company, 1909, vol. 6, p. 517. Hutchinson, R.: Fainting Attacks in Children, Brit. J. Child. Dis. **13**:161 (June) 1916.

the experience of nearly every one, at least in the form of "faint feeling." In two groups of unselected women interviewed (at Aledo and Mendota) questions were asked concerning fainting, its frequency and the attributed cause. When the replies were in the form of "faint feeling" or "attacks of weakness," they were not included. There is not any way of knowing whether in the episodes reported as "fainting attacks" transient loss of consciousness always occurred. As will be seen later, however, there is with fainting, as with periodic headaches, a distinct relation to explosive infantile symptoms.

In Mendota, twenty-eight of eighty mothers had fainted once or oftener (35 per cent), and in Aledo twenty-three of 102 (22 per cent).

TABLE 11.—*Relationship of Periodic Headache and Fainting to Infantile Convulsions (Mendota)*

Infantile Convulsions	Family History
1. Male, aged 14 years; first of three children; fourteen "spasms" in one day at age of about 18 months, no cause assigned	Youngest brother a breath-holder; father fainted five times, attributed to heat
2. Male, aged 5 years and 9 months; third of four children; one infantile convulsion at age of 3 years, attributed to eating salmon	Mother and maternal aunt had periodic headaches
3. Male, only child, aged 1 year and 4 months, convulsions at age of 12 months, attributed to overfeeding	Mother and maternal grandmother had periodic headaches; mother fainted twice, attributed to exhaustion
4. Female, aged 12 years; first of four children; two convulsions at age of about 6 months, attributed to indigestion	Mother and maternal grandmother had periodic headaches
5. Female, aged 8 years; sister of patient 4; from two to three convulsions at age of about 12 months, attributed to indigestion	Maternal grandmother fainted occasionally in youth
6. Female, aged 2 years and 1 month; only child; two convulsions, one at age of 18 months, the other at age of 24 months, both with fever; also vomiting spells	Mother and maternal grandmother had periodic headaches; maternal aunt a fainter
7. Second of five children; aged 8 years; convulsion at age of 30 months, with fever	Mother and maternal grandmother had severe periodic headaches; mother also had attacks of "faint feelings"

Of the fifty-one, twenty-three had fainted only once or twice; twenty-eight had fainted three times or oftener.

Of the two groups in table 10 it can be stated chiefly that there is probably a significantly larger number of fainting attacks in pregnancy and with "no cause assigned" in the group in which fainting occurred three or more times. Otherwise, it is difficult to draw conclusions, except that when fainting occurs frequently in any one case several causes are likely to be assigned. A few of the women with frequent attacks had them during pregnancy only; likewise a few had had recurrent fainting attacks since childhod, every few months, without a cause assigned. Of the causes listed in both groups, the most frequent are conditions which have to do with the generative organs (16 out of 71 total faints) and pain (14 of 71), including the group "after operation" under the heading of "pain."

Of the twenty-three patients from Aledo, ten also reported periodic headache (43 per cent), and in the group from Mendota, ten of twenty-eight patients (35 per cent).

The relationship of periodic headache and fainting to certain "explosive phenomena" in childhood was recorded for two communities and will be presented separately for each one, since the reliability of the figures is more easily tested in that way.

At Mendota, eighty mothers were seen and data was secured on their 188 living children. Of these, ninety-nine were seen at the Better Baby Conference. Seven of the 188 children, in six families, had had infan-

TABLE 12.—*Relationship of Periodic Headache and Fainting to Breath-Holding in Childhood (Mendota)*

Breath-Holding	Family History
1. Male, aged 4 years and 10 months; second of three children; breath-holding age from 12 to 18 months	Brother, aged 14 years, had infantile convulsions; mother faints
2. Male, aged 3 years and 5 months; first of two children; breath-holding in period from age of 9 to 24 months	Mother has periodic headaches; fainted once
3. Male, aged 7 months; only child; breath-holding period from age of 4 months to present	Mother fainted on five occasions
4. Male, aged 24 months; only child; breath-holding from age of 15 to 22 months	Mother and maternal grandmother faint
5. Male, aged 4 years; only child; breath-holding from third week to age of 2½ years, especially from sixth to twelfth month	Father has periodic headache and faints; two paternal aunts likewise
6. Female, first of two children, aged 8 years; breath-holding age from 1 to 4 years	Mother, maternal aunt and maternal grandmother have periodic headache; mother also faints
7. Brother of patient 6, aged 3 years and 2 months; occasionally breath-holding for past six months	
8. Male, aged 7 months; second of two children; breath-holding from age of 1 to 2 months	Mother has periodic headache and faints
9. Male, aged 2 years and 7 months; occasional breath-holding	Negative
10. Male, only child, aged 17 months; onset at age of 15 months, but three times in past month	Mother and maternal grandmother faint
11. Male, aged 2 months; last of six children; breath-holding since second month	Mother and maternal grandmother faint; father has periodic headache

tile convulsions (3.7 per cent). Instances of fainting or periodic headache had occurred in all these families. Periodic headache had occurred in five mothers and maternal grandmothers; fainting, in one father, one mother, one maternal aunt and one maternal grandmother.

Eleven of the 188 children had histories of breath-holding (5.8 per cent). Of their ten families, nine gave instances of fainting (in two fathers, in seven mothers and in five other members; five gave instances of periodic headache in two fathers, in three mothers and in four other members).

Five of the 188 children had histories of head-banging, or head-slapping (2.6 per cent). Of their five families, four reported instances of fainting, periodic headache or head-banging; one did not present any of these symptoms.

In fifty-eight of the eighty families the history of the children was negative for convulsions, head-banding and breath-holding. In each of the remaining twenty-two families one or more children presented a history of these symptoms (and in one case fainting). In table 14, instances of headache or fainting and the symptoms of the children (head-banging, etc.) are tabulated with regard to the parents.

"Negative" indicates that neither parent had any of the symptoms enumerated. "Headache" indicates mild or severe periodic headache in

TABLE 13.—*Relationship of Periodic Headache and Fainting to Head-Banging in Childhood (Mendota)*

Head-Banging	Family History
1. Male, aged 4 years and 6 months; second of three children; head-banging several times when about 1 year old	Mother and maternal grandmother frequently fainted
2. Female, aged 1 year and 11 months; fourth of four children; head-banging occasionally between ages of 1 and 2 years	Negative
3. Female, aged 17 months; only child; head-slapping, onset at age of 12 months and continuing	Father and paternal grandfather had periodic headaches
4. Male, aged 17 months; only child; head-banging several times in past few months (also a breath-holder)	Mother and maternal grandmother faint
5. Male, aged 1 year and 2 months; only child; head-banging onset at age of 9 months and continues	Head-banging of father and mother in infancy; maternal grandmother had periodic headaches

TABLE 14.—*Fainting and Headache in the Parents of Children With and Without the Symptoms Studied (Mendota)*

	Both Parents Negative*		Infantile Convulsion, etc. in Parents		Headache* in Parents		Fainting in Parents		Both Headache and Fainting* in Parents	
	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%
Parents of negative* children (58 families, 130 children)	23	39.7	0	0.0	14	24.1	13	22.4	8	13.8
Parents of positive children (22 families, 58 children)	2	9.1	2	9.1	6	27.3	5	22.7	7	31.8

* "Negative" indicates that neither parent had any of the symptoms enumerated. "Headache" indicates mild or severe periodic headache in one or both parents. "Headache and fainting" indicates that either or both parents had one or the other of these symptoms combined. Only one instance of the symptoms or combinations mentioned are tabulated for each family.

one or both parents. "Headache and fainting" indicates that either or both parents had one or the other of these symptoms combined. Only one instance of the symptoms or combinations mentioned is tabulated for each family.

From table 14 it is seen that parents of children without the symptoms studied are somewhat freer from periodic headaches and fainting than the others, and considerably freer from combinations of fainting and headache. Both parents of "negative" children are much more frequently "negative" than are the parents of "positive" children.

When headaches and fainting occur they are less severe in the parents of negative children, as indicated by their frequency and combination. We divide periodic headaches into two groups: those occurring oftener than once a month, indicated by *H*, and those occurring less frequently than once a month, indicated by *h*. Fainting is also grouped on the basis of frequency; twice or less in the life history of the person, indicated by *f*, and oftener, indicated by *F*.

As shown in table 15, parents of children who are free from the symptoms studied have milder periodic headaches and fainting, as determined by frequency.

Ten mothers or fathers who had periodic headaches less frequently than once a month had twenty-seven children presenting the following symptoms: two, infantile convulsions; none, head-banging; none, breath-holding, and none, other "attacks" (7.4 per cent). Twenty-three mothers

TABLE 15.—*Frequency of Headaches and Fainting in the Parents of Both Groups (Mendota)**

	h		H		f		F		Combined fh, Fh, Hf		FH	
	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%
Parents of 130 negative children	6	10.3	8	13.7	8	13.7	5	8.7	6	10.3	2	3.5
Parents of 58 positive children	1	4.6	5	22.7	0	0.0	5	22.7	3	13.6	4	18.2

* H indicates periodic headaches occurring oftener than once a month; h, those occurring less frequently than once a month. F indicates fainting oftener than twice in the life history of the patient; f, twice or less often.

or fathers who had periodic headaches oftener than once a month had fifty-nine children presenting the following symptoms: five, infantile convulsions; one, head-banging; five, breath-holding, and two, other periodic attacks—thirteen instances in all (22 per cent). That is, when we classify parental groups on the basis of frequency of periodic headaches, we find significantly greater frequency of the symptoms studied in the children of the groups of parents in whom headaches are more frequent (table 16).

At Aledo, 102 mothers were interviewed and data were secured on their 234 living children. Of these children, 123 were seen. A history of infantile convulsions was obtained in ten (4.2 per cent of the 234). These ten children were in nine families, and in eight of the nine one or more other members had had infantile convulsions, periodic headaches or fainting (table 17).

It will be seen in table 17, as in the other tables covering the Aledo group, that children with breath-holding, head-banging, temper, infantile convulsions or recurrent attacks, in the form of fainting spells, dizziness

TABLE 16.—*Frequency of Headache in the Parents and of Explosive Symptoms in Their Children (Mendota)*

Occurrence of Headache in Mothers or Fathers	Number of Instances in Children of					
	Number of Families	Number of Children	Infantile Convulsions	Head-Banging	Breath-Holding	Other Periodic Attacks
Less frequent than once a month	10	27	2	0	0	0
Once a month or oftener, with nausea and vomiting	7	19	1	1	1	0
Nausea only	3	7	1	0	1	1
With dizziness	2	9	2	0	0	0
With visual symptoms	5	11	0	0	3	1
With combination of foregoing symptoms	2	6	1	0	0	0
Without foregoing symptoms	4	7	0	0	0	0
Total	23	59	5	1	5	2

TABLE 17.—*Relation of Infantile Convulsions in Ten Children to Other Nervous Episodes in the Families (Aledo)*

Infantile Convulsions	Family History
1. Male, aged 3 years and 11 months; only child; from five to 10 convulsions at age of 18 months, no cause assigned	Father had infantile convulsions attributed to worms
2. Male, aged 26 years; first of five children; premature; convulsions at age of 15 months, attributed to teething	Negative
3. Female, aged 3 years and 11 months; only child; one convulsion at age of 24 months, attributed to indigestion	Father had fainting spells whenever "stomach upset" occurred, i. e., vomiting, from ten to twelve times; mother and maternal aunt had periodic headaches with dizziness
4. Male, aged 3 years and 1 month; second of two children; three convulsions at age of 24 months, 30 months and 36 months, respectively, no cause assigned (also vomiting spells from sixth to twelfth month)	Mother had severe periodic headaches with scotomas since age of 25 years; three paternal aunts had fainting spells
5. Male, aged 3 years and 2 months; only child; three convulsions when 4 days old, then daily for four days; none since (breath-holding also at age of 6 to 8 months)	Mother fainted three times after vaccination and following operation; maternal aunt had infantile convulsions
6. Male; age not given; second of five children; fifteen convulsions on second day after birth	A brother (fifth child) is a breath-holder; mother fainted three times (during pregnancy only)
7. Male; second of two children; four convulsions at age of 3 months (vomiting attacks followed each)	Mother had periodic headaches and fainted once; maternal aunt fainted several times
8. Aged 7 years; first of two children; one convulsion at age of 30 months, attributed to eating grapes	Mother fainted once after childbirth; a maternal aunt had infantile convulsions
9. Female, aged 3 years and 4 months; last of four children; one convulsion during "flu" at age of 12 months	
10. Sister of patient 9, aged 6 years; second of four; two convulsions, first at age of 24 months, attributed to teething, second at age of 30 months, attributed to "flu"	Father had infantile convulsions; mother and maternal grandmother had periodic headaches

or vomiting, have parents who faint and have periodic headaches much more frequently than the parents of children who are free from the symptoms selected; and that parents who faint and have periodic headaches have children who present the symptoms mentioned much more frequently than parents who are free from fainting and periodic headache; that parents selected on the basis of the frequency of fainting or periodic headache have children whose frequencies of nervous episodes are more or less in proportion to the severity of the parents' symptoms. Studies of both groups (Aledo and Mendota) are combined in tables 23, 24 and 25.

TABLE 18.—*Relationship of Perodic Headache and Fainting to Breath-Holding in Childhood (Aledo)*

Breath-Holding	Family History
1. Male, aged 8 months; only child; breath-holding, with opisthotonos	Mother fainted once at age of 9 years
2. Male, aged 2 years and 1 month; first of two children; breath-holding from age of 7 to 8 months, during temper (also head-banging with temper)	Mother had periodic headaches
3. Male, aged 3 years and 2 months; breath-holding at from 6 to 8 months of age (also infantile convulsions)	Maternal aunt had infantile convulsions; mother fainted three times
4. Female, aged 2 years and 1 month; youngest of five children; breath-holding when angry since age of 12 months	Brother, second child, had infantile convulsions; mother fainted three or four times during pregnancy
5. Female, aged 2 years and 1 month; youngest of three; breath-holding when angry since age of 12 months	Brother, second child, had infantile convulsions; mother fainted three or four times during pregnancy
6. Male, aged 10 months; youngest of three; breath-holding age of 6 to 7 months (also head-banging)	Mother fainted many times up to age of 18 years (is now 31)
7. Female, aged 4 years and 11 months; only child; breath-holding (also head-banging) up to age of 30 months	Mother and maternal grandmother had severe periodic headaches
8. Male, aged 3 years and 1 month; only child; breath-holding continues	Mother fainted three times when 18 years old; patient, mother and sister had periodic headaches; paternal aunt had infantile convulsions
9. First of five children; age not recorded; a breath-holder	Mother had severe, periodic headaches

Nine of the 234 children gave histories of breath-holding (3.8 per cent). Of their nine families, eight gave instances of fainting, periodic headache or infantile convulsions (table 18).

Nine of the 234 children gave histories of head-banging (3.8 per cent). Of their nine families, seven reported instances of fainting, periodic headache or infantile convulsions (table 19).

From the data shown in tables 20 and 21 we reach the same conclusion as that drawn from tables 14 and 15 relating to families of Mendota.

Sixteen mothers or fathers (i.e., sixteen parental pairs) who had periodic headaches less frequently than once a month had thirty-eight children who presented the following symptoms: one, infantile convul-

TABLE 19.—*Relationship of Periodic Headache and Fainting to Head-Banging in Children (Aledo)*

Head-Banging	Family History
1. Male, aged 1 year and 6 months; only child; occasional head-banging in past month	Mother fainted once at age of 8 years, attributed to heat
2. Male, aged 2 years and 1 month; head-banging since age of 7 to 8 months (also breath-holding)	Mother had periodic headaches with vomiting from age of 10 to 13 years
3. Male, aged 1 year and 10 months; only child; head-banging from sixth to twelfth month	Mother fainted once at age of 9 years, following an operation
4. Male, aged 10 months; only child; head-banging on average of once a week; onset at age of 5 months	Mother and maternal grandmother had periodic headaches with vomiting
5. Male, aged 10 months; youngest of three children; head-banging at age of 6 to 7 months (also breath-holding)	Mother fainted many times until age of 18 years
6. Female, aged 4 years and 11 months; only child; head-banging to age of 30 months	Mother had periodic headaches with nausea; maternal grandmother likewise, with dizziness
7. Female, only child, aged 1 year and 4 months; occasional head-banging	Negative
8. Female, aged 2 years; youngest of three children; head-banging to age of 12 months	Mother frequently fainted; also had periodic headaches
9. Male; age not recorded; younger of two children; head-banging now	Negative

TABLE 20.—*Fainting and Headache in the Parents of Children With and Without the Symptoms Studied (Aledo)*

	Both Parents Negative*		Either Parent Had Infantile Convulsions		Either Parent Had Headache		Either Parent Fainted		More Than One Symptom in Either or Both Parents	
	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%
Families of negative children (80 families, 184 children).....	45	56.3	3	3.7	18	22.5	8	10.0	6	7.5
Families of positive children (22 families, 50 children).....	4	18.2	1	4.6	5	22.7	7	31.8	5	22.7

* "Negative" indicates that neither parent had any of the symptoms enumerated. "Headache" indicates mild or severe periodic headache in one or both parents. "Headache and fainting" indicates that either or both parents had one or the other of these symptoms combined. Only one instance of the symptoms or combinations mentioned are tabulated for each family.

TABLE 21.—*Frequency of Headaches and Fainting in the Parents of Both Groups (Aledo)*

	h		H		f		F		Any Combination of f, F, h, H* and Infantile Convulsions		FH	
	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%
Families of negative children (80 families, 184 children).	10	12.5	18	22.5	2	2.5	8	10.0	4	5.0	2	2.5
Families of positive children (22 families, 50 children)..	0	0.0	5	22.7	4	18.2	3	13.6	3	13.6	2	9.9

* H indicates periodic headaches occurring oftener than once a month; h, those occurring less frequently than once a month. F indicates fainting oftener than twice in the life history of the patient; f, twice or less often.

sions; one, head-banging; none, breath-holding, and none, other attacks (5.2 per cent). Seventeen mothers or fathers who had periodic headaches oftener than once a month had thirty-five children who presented the following symptoms: two, infantile convulsions; three, head-banging; four, breath-holding, and four, other periodic attacks—thirteen instances in all (37 per cent) (table 22).

TABLE 22.—*Frequency of Headache in the Parents and of Explosive Symptoms in Their Children (Aledo)*

Occurrence of Headache in Mothers or Fathers	Number of Instances in Children of					
	Number of Families	Number of Children	Infantile Convulsions	Breath-Holding	Head-Banging	Other Periodic Attacks
Less frequent than once a month	16	38	1	..	1	..
Once a month or oftener, with vomiting	6	11	..	1	2	..
With nausea only	1	1	..	1	1	1
With dizziness	0	0	..	..	..	..
With visual symptoms	4	6	1	1	..	2
With combination of foregoing symptoms	4	11	1	..	..	1
Headache without foregoing accompanying symptoms	2	6	..	1	..	..
Total	17	35	2	4	3	4

TABLE 23.—*The Frequency of Explosive Symptoms in Children of Parents Who Had Periodic Headache and in Children of Parents Who Fainted, When These Symptoms Were Not in Combination*

	Infantile Convulsions	Breath-Holding	Head-Banging	Other Periodic "Attacks"	Total Cases	Total Percentage of Children
			Aledo			
Parents who had periodic headache only; no fainting (21 families, 52 children)	1	3	3	3	10	19
Parents who fainted only (15 families, 30 children)	3	4	2	2	11	37
			Mendota			
Parents who had periodic headache only; no fainting (19 families, 55 children)	5	0	0	1	6	11
Parents who fainted only (18 families, 46 children)	1	7	2	1	11	26

Table 23 is a comparison of the frequency of explosive symptoms in children of parents who had periodic headache and with those in children of parents who fainted, when these symptoms were not in combination.

In table 23 a symptom is counted but once for each family. When, for example, headache or fainting occurs in each parent it is counted once. The table indicates that the explosive phenomena covered in this study are more likely to be found in children of parents who have had fainting attacks than in parents who have periodic headaches.

As in the case of periodic headaches, we found an increase in frequency of the attacks in the children of parents in whom the fainting attacks are increased in frequency. This is indicated in table 24.

In these cases instances of fainting were included, whether or not in combination with periodic headache. Though the number of cases is not large, the consistency of the results is corroborative. Children whose parents fainted frequently were more likely to have infantile convulsions, attacks of breath-holding, temper with head-banging or other attacks

TABLE 24.—*The Frequency of Explosive Symptoms in Children of Parents Who Fainted One or Two Times and in Children of Parents Who Fainted More Than Two Times (Aledo and Mendota Combined)*

	Number of Children With					
	Infantile Convulsions	Head-Banging	Breath-Holding	Other Periodic "Attacks"	Total Cases	Total Percentage of Children
Parents who fainted one or two times (22 families, 46 children)	3	2	2	1	8	17
Parents who fainted three or more times (30 families, 63 children)	4	3	13	2	22	35

TABLE 25.—*Summary of Results of Study Made*

	Number of Cases	Percentage
422 children (in two towns)		
Infantile convulsions	97*	4.03
Breath-holding	20	4.74
Head-banging	14	3.32
552 mothers (in five towns)		
Periodic headache	222	40.20
182 mothers		
Fainting: one or more instances	51	28.0
Fainting: three or more instances	28	15.4

* Added to our previous lists, the number of infantile convulsions totals 68, or 3.81 per cent of 1,786 unselected children.

in the form chiefly of recurrent vomiting or fainting. There are not enough cases to determine any possible difference in the frequency of these symptoms in children of families in which fainting is frequent as contrasted with families in which migraine occurs frequently.

One may conclude from this study that the explosive symptoms in question are correlated with either or both of the two symptoms, parental fainting and periodic headache, and that they occur more frequently when the parental symptoms are in combination or of increased severity as determined, at least, through frequency.

COMMENT

Certain relationships considered in this study have been noted by many writers. The idea of temper tantrums, for example, being possibly equivalent to convulsions or bound up in some way with epilepsy is old. Maudsley regarded manifestations of temper as "psychic convulsions"; LeGrand du Saule thought that "strong attacks of anger" were related to epilepsy or epileptoid states; M. de Fleury observed displays of temper especially in the relatives of epileptic persons and in those who had attacks resembling epilepsy. Laumonier [9] expressed the belief that the difference between strong temper and epilepsy is a difference in degree, and has noted that a partial loss of consciousness sometimes occurs in temper.[10] As equivalents of migraine, they have been frequently described.[11]

Of children referred to the physician because of violent temper it is interesting to note the instances of epilepsy, alcoholism and similar outbursts of temper in the parents. Such cases were cited by Healy,[12] Morse,[13] Moyle [14] and others. Fainting spells have also been regarded as equivalents of temper in some cases.[15]

Head-banging and breath-holding occurred in about 4 per cent of the 422 children listed in this paper. They represent abnormal manifestations of temper. The tests of normality of temper according to Ribot [16] are based on its violence, duration and presence of rational motive. A clinical standard of normal temper has been attempted.[17]

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9. Laumonier, J.: La Colére et son traitement, Bull. gén. de thérap. **160**: 330 (July-Dec.) 1910. A discussion of the somatic basis of temper may be found in this article.

10. De Fleury, M.: Les maladies des enfants, in Maladies du système nerveux, Paris, V. Hutinel, 1909, vol. 5, p. 837.

11. Spaulding, E.: Tantrums in Childhood and Related Emotional Reactions, Arch. Pediat. **41**:185, 1924.

12. Healy, W.: The Individual Delinquent, Boston, Little, Brown & Co., 1924, p. 416.

13. Morse, J. L.: Case Histories in Pediatrics, ed. 2, Boston, W. M. Leonard, 1913, case 156.

14. Moyle, H. B.: Mental Disturbances of Childhood (case 3), Canad. J. Ment. Hyg. **3**:249 (Oct.) 1921.

15. Behavior Problems and the Preschool Child, Tr. Am. Child. Hyg., 1922, p. 157. Stier, in a follow-up study of thirty-three cases, made a correlation of fainting, as well as of night terrors, dizziness and breath-holding spasms in children and parents. Stier, E.: Ueber Ohnmachten und ohnmachtsähnliche Anfälle bei Kindern, Deutsche med. Wchnschr. **46**:372, 1920.

16. Ribot, T.: The Psychology of the Emotions, London, Walter Scott, 1897, p. 223.

17. Levy, D. M.: The "Habit Clinic," Institutional Quarterly, Department of Public Welfare, State of Illinois, December, 1923. Hall, G. S.: A Study of Anger, Am. J. Psychol. **10**:16, 1899.

The term "head-banging" was first used by Samuel Gee.[18] In his three cases, the head-banging was associated not with outbursts of temper but with head-rolling habits and the like, quite a different symptom from that considered here. Several writers think that head-banging is a symptom of headache or middle ear disease or of purely emotional outbursts. No satisfactory theory regarding this curious type of temper appears in the literature.

Breath-holding occurs oftenest as a display of temper that begins with crying. Mothers usually answer questions about breath-holding promptly, having in mind breath-holding to the point of marked blueness or also transient loss of consciousness. Such phrases as "holding his breath for a long while," or "he cried so angrily he couldn't catch his breath" require further questioning to elicit symptoms of marked cyanosis and loss of consciousness. Breath-holding to the point of flushing commonly occurs in tantrums of temper and is not included in our lists.[19] When breath-holding lasts more than several seconds, it may be followed by convulsions. The differentiation from epilepsy is sometimes difficult.[20]

The differentiation of breath-holding from laryngismus, as well as the literature on this subject, has been thoroughly covered by Ibrahim. He does not find in this condition any evidence of epilepsy or tetany, and considers the basis an inherited neuropathic state, and the development of the act a pathologic conditioned response. Interestingly, three of the patients he described developed epilepsy later in life. He preferred the name "emotional respiratory convulsions." [21]

SUMMARY

The frequency of periodic headache in groups of apparently normal women in five communities was as high as 40.2 per cent, and this percentage probably is lower than the actual frequency. These headaches likely were largely migraine. At least they were similar to this disorder in periodicity, chronicity, duration of attack and family history, and lent themselves to similar classification with regard to accompanying symptoms. Classified on the basis of time taken out of work, however, the majority of periodic headaches caused slight incapacity.

Current medical statistics of migraine are based on cases in which the symptoms were of greater frequency, duration or severity than usual,

18. Gee, S.: Miscellanies, St. Bartholomew's Hosp. Rep. **22**:96, 1886.

19. Watson, J. B., and Watson, R. R.: Studies in Infant Psychology, Scient. Month. **13**:505, 1921.

20. Abt, I. A.: Breath-Holding in Infants, Tr. Am. Pediat. Soc. **30**:25, 1918.

21. Ibrahim, J.: Ueber respiratorische Affektkrämpfe in frühen Kindesalter (das sogenannte "Wegbleiben" der Kinder), Ztschr. f. d. ges. Neurol. u. Psychiat. **5**:388, 1911.

especially with progressive severity and incapacity. That is, such statistics represent only a fraction, possibly a small fraction, of the total cases.

The frequency of fainting in apparently normal women was 28 per cent in our series.

Parents who fainted or who had periodic headaches were more likely to have children who had infantile convulsions, temper with head-banging or breath-holding, and other recurrent attacks, especially spells of vomiting and fainting. Parents who fainted were more likely to have such children than parents who had periodic headache but remained free from fainting. Parents who had frequent periodic headaches were more likely to have such children than those whose headaches were infrequent. The same was true of fainting.

Conversely, children who had "explosive symptoms" were more likely to have parents who fainted and had periodic headache than children who were free from such symptoms. The "explosive symptoms"—infantile convulsions, temper with breath-holding and temper with head-banging—were in correlation with each other and with fainting and periodic headache in the parents.

In this paper no attempt has been made to go further than to establish the frequencies of these symptoms and their correlations.

THE AMMONIACAL SILVER SOLUTIONS USED IN NEUROPATHOLOGY

THEIR STAINING PROPERTIES, CHEMISTRY AND METHODS OF PREPARATION *

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The methods of staining with silver salts, developed so largely by Fajersztajn and Bielschowsky in Germany, and by Ramón y Cajal and Del Rio-Hortega in Spain, are receiving increasing attention. Several procedures have been described for preparing the ammoniacal silver solutions which are used in these methods, and selective staining results have been attributed to each. The conflicting claims have led at times to actual controversy, and the present investigation aims to clarify this subject.[1]

(1) The method of Fajersztajn,[2] described in 1901, is of both historical and theoretical interest (as will be shown later). To a weak solution (exact concentration not given) of silver nitrate ($AgNO_3$), Fajersztajn added ammonia until the brown precipitate which formed at first had completely redissolved. He then added more silver nitrate until a precipitate began to form again; the solution, supposedly "freed of excess ammonia" in this way, was filtered through hardened "analytical" filter paper.

(2) In 1902, Bielschowsky introduced his classic method for the silver staining of the axis-cylinder.[3] His method of preparing the silver solution has undergone slight alterations at various times; as learned from him personally during the fall of 1926, it may be outlined as follows:

To 5 cc. of 10 per cent silver nitrate are added 8 drops of a 40 per cent solution of sodium hydroxide in a glass-stoppered, graduate. This is shaken well. Then a solution of 25 per cent ammonia (specific gravity about 0.9) is added rapidly, drop by drop, with almost constant shaking. The addition of ammonia is stopped when the large brown granules suddenly disappear, leaving a muddy brown solution which is barely translucent but in which individual granules are not clearly visible. Occasionally one more drop of ammonia may be added after this point is reached, but usually the resolution of the silver is ended here. This solution is diluted to 25 cc. with distilled water, and before using is filtered through ordinary filter paper which has been rinsed with distilled water.

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* From the Laboratories of the Rockefeller Institute for Medical Research.

1. It is a privilege to express here our gratitude to Professors Bielschowsky, Ramón y Cajal, and Del Rio-Hortega for generous help and instruction in the details of these methods, during the spring, summer and fall of 1926 (L. S. K.).

2. Fajersztajn, J.: Ein neues Silberimprägnationsverfahren als Mittel zur Färbung der Axenzylinder, Neurol. Centralbl. **20**:98, 1901.

3. Bielschowsky, M.: Die Silberimprägnation der Axenzylinder, Neurol. Centralbl. **21**:579, 1902.

(3) The essential difference between the method of Ramón y Cajal and the foregoing method is the thorough washing of the precipitate which Cajal recommends.[4] To 10 cc. of a solution of 10 per cent silver nitrate are added 12 drops of 40 per cent sodium hydroxide in a graduated cylinder. Distilled water is added to the precipitate, and after vigorous shaking the precipitate is allowed to settle again and the supernatant water is decanted. This is repeated at least five times, after which distilled water is added to make a total volume of 60 or 70 cc. Concentrated ammonia is then added, drop by drop, with frequent shaking, until the precipitate is almost, but not completely, dissolved. The undissolved residue is allowed to remain in order to avoid as far as possible an "excess" of ammonia.

(4) Del Rio-Hortega[5] introduced the use of sodium or lithium carbonate in place of sodium hydroxide or ammonia for the initial precipitation of the silver. To 5 cc. of 10 per cent silver nitrate he adds from 15 to 20 cc. of 5 per cent sodium carbonate (Na_2CO_3), or of a mixture of sodium and potassium carbonate, or of a saturated solution of lithium carbonate. Del Rio-Hortega believes that the yellow-white precipitate which forms tends to darken quickly in the light, necessitating rapid solution with ammonia. For this reason, he quickly adds strong ammonia, caring less about the presence of an excess than do the other workers. The resulting solution may at times be used without dilution; at others, with dilution to 30 or 40 cc., or to 75 cc.

The chemistry of such solutions has been the subject of many physicochemical investigations, which indicate that in all of these ammoniacal solutions of silver compounds, the silver exists largely in the form of the complex silver-ammonia-cation $[Ag(NH_3)_2^+]$. (Full references are given in an article by Mellor.[6]) In other words, the silver ion is the same whichever of these methods is used in preparing it; but the activity of the ion will be found to show striking variations, depending on the other constituents of the solution.

These methods of preparation may be grouped under three headings. When ammonia alone is used both for precipitation and solution, the final solution may best be spoken of as "ammoniacal silver nitrate"; the chief product of the reaction is silver diamminonitrate $[Ag(NH_3)_2NO_3]$. When the precipitate is produced with sodium hydroxide, and ammonia is used only to redissolve, one may speak of the solution as "ammoniacal silver hydroxide"; the chief constituent is the strongly dissociated base, silver diammino-hydroxide $[Ag(NH_3)_2OH]$. With sodium carbonate as precipitant, followed by ammonia, the solution may be called "ammoniacal silver carbonate," with silver diammino-carbonate $[(Ag(NH_3)_2)_2CO_3]$ as its main component.

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4. Ramón y Cajal, S.: Elementos de histologia normal y de tecnica micrografica, ed. 8, Madrid, 1926, p. 729.

5. Rio-Hortega, P. Del.: Noticia de un nuevo y fácil método para la coloración de la neuroglia y del tejido conjuntivo, Trav. del. lab. de inv. biol. **15**:378, 1918.

6. Mellor, J. W.: A Comprehensive Treatise on Inorganic and Theoretical Chemistry, London, Longmans, Green & Co., 1923, vol. 3, p. 382.

It will be shown that the amount of ammonia required to prepare these solutions varies with, and is actually a measure of, their alkalinity; and that the variations in staining activity correlate with this.

AMOUNT OF AMMONIA NECESSARY FOR COMPLETE SOLUTION OF THE SILVER COMPOUND, AND THE EFFECT OF DIFFERENT HYDROXYL ION CONCENTRATIONS ON THIS

Ammonia Used Alone ("Ammoniacal Silver Nitrate").—From the formula of the complex silver cation $[Ag(NH_3)_2^+]$, it is evident that two molecules of ammonia are required for combination with each atom of silver. It was found, however, that 10 cc. of 1.2 molar ammonia solution, when added to 10 cc. of 0.6 molar silver nitrate[7] (i. e., a ratio of two molecules of ammonia to one atom of silver) left an undissolved residue of brown precipitate, which went into solution only on the addition of 0.3 cc. more of the ammonia. This yields the ratio 2.06:1, for the ratio of molecules of ammonia to molecules of silver nitrate, which agrees closely with the results of previous investigators:

	Mean
Prescott: Chem. News **42**:31, 1880	2.06
Reychler: Ber. d. deutsch. chem. Gesellsch. **16**:990, 1883	2.03
Draper: Pharm. J. **17**:487, 1886	2.06
Hertz: Z. anorg. Chem. **67**:248, 1910	2.11
	2.065

The explanation of the excess ammonia is found in the following considerations: (a) Silver nitrate reacts directly with ammonia molecules in solution, to give silver diammino-nitrate, $AgNO_3 + 2NH_3 = Ag(NH_3)_2NO_3$. (b) This reaction, however, stops short of completion, because the complex ion, $Ag(NH_3)_2^+$, although stable, dissociates to a small extent to yield significant concentrations of silver ion (Ag^+) and of ammonia free in solution. (c) Ammonia in solution exists in three forms: as molecules of ammonia, as hydrated ammonia ($NH_3 + H_2O = NH_4OH$), and as the dissociated ions of NH_4OH, NH_4^+ and OH^-.[8] As a result, there occur in the solution concentrations of both silver and hydroxyl ions which are sufficient to cause a precipitate of the slightly soluble substance, silver hydroxide. This situation is represented in formula 1.

7. In the present investigation, a 0.6 molar solution of silver nitrate (10.2 per cent) has been used, because it closely approximates the 10 per cent solution customarily used in histologic laboratories. An ammonia solution of 1.2 molar strength has also been used, so that equal volumes of these two solutions were chemically equivalent. The preparation of these solutions is described later.

8. It is probable that ammonium hydroxide is itself a strong base, and therefore largely dissociated, but that only a small amount of ammonium hydroxide forms, so that the total behavior of an ammonia solution is that of a weak base.

Formula 1

$$\begin{array}{l} Ag(NH_3)_2NO_3 \rightleftarrows NO_3^- + Ag(NH_3)_2^+ \rightleftarrows 2NH_3 + \quad Ag^+ \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad + \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad H_2O \quad + \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad \downuparrows \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad NH_4OH \rightleftarrows OH + NH_4^+ \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad \downuparrows \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad AgOH \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad \text{(dissolved)} \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad \downuparrows \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad AgOH \rightleftarrows \tfrac{1}{2}\,(Ag_2O + H_2O) \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad \text{(solid)} \end{array}$$

(d) Since, in general, the dissociation of a substance is inhibited by the presence of one of the products of dissociation, the addition of an excess of ammonia will depress the dissociation of $Ag(NH_3)_2^+$, and will therefore decrease the concentration of silver ion arising from it. And since, moreover, the addition of excess ammonia causes a proportionally greater decrease in the concentration of silver ion than the concomitant increase in hydroxyl ion, the solution of the silver hydroxide (or oxide) precipitate is made possible when a sufficient amount of ammonia has been added. In the present case, as has been said, this occurs with an excess of 0.3 cc. of 1.2 molar ammonia.

To clarify the subsequent discussion of the effects of adding sodium hydroxide to this reaction, it is necessary to explain the principles of precipitation and solution a little further. For the precipitation of a substance from solution, it is necessary that the ions of this substance be present in quantities such that when the two concentrations are multiplied together, the product is greater than a certain figure, which is called the "solubility product—S" of the substance. This solubility product is an experimentally determined value which is characteristic for any compound. It is the product of the concentrations of the ions in a pure saturated solution of the compound.

It should be clear, therefore, that, after dissolving a compound in water to the limit of its solubility, if anything occurs to increase the concentration of one of its ions, in order to hold the compound in solution there must be produced an exactly proportionate decrease in concentration of the other ion, since the product of these two concentrations cannot exceed this constant value if the substance is to remain in solution. It will be seen, in the next section, that the use of sodium hydroxide, by raising the concentration of hydroxyl ions, necessitates the use of a much larger excess of ammonia in order to secure a sufficient decrease in the concentration of silver ions to make possible complete solution of the precipitated silver oxide.

With Sodium Hydroxide and Ammonia ("Ammoniacal Silver Hydroxide").[9]—From the foregoing discussion it should be evident that

9. In discussing these solutions, it is preferable to speak of the hydroxide, rather than of the oxide, because when they are in solution both the silver oxide and the ammoniacal silver oxide, like the oxides of all strong bases, largely take the form of the hydroxide; and it is in solution as the hydroxide that all of their reactions occur.

a clear solution of ammoniacal silver nitrate inevitably contains an excess of ammonia, besides definite concentrations of silver and hydroxyl ions. If to such a solution there is added an equivalent amount of sodium hydroxide (i. e., in this case, 10 cc. of 0.6 molar), the strong base markedly increases the hydroxyl ion concentration. The product of the concentrations of silver ion and hydroxyl ion becomes much greater than the solubility product of silver hydroxide, and as a result there is a precipitation of the major portion of the silver present in the solution. The precipitated oxide, nevertheless, may be returned to solution by adding a still greater excess of ammonia. This ammonia further represses the dissociation of the complex ion, $Ag(NH_3)_2^+$, and thereby reduces the silver ion concentration until the product of the two ions is no longer greater than the solubility product of silver hydroxide, whereupon a return to solution becomes possible. Actually, 5.5 cc. more of 1.2 molar ammonia were required (table 1). This corresponds to a value of 3.34 for the ratio $NH_3 : AgNO_3$, which is in good agreement with the results of former investigations:

	Mean
Whitney and Melcher: J. Am. Chem. Soc. **25**:70, 1903	3.28
Euler: Ber. d. deutsch. chem. gesellsch. **36**:1854, 1903	3.03
Olmer: Bull. Soc. chim. **35**:333, 1924	3.32
	3.210

TABLE 1.—*Cubic Centimeters of 1.2 Molar Ammonia Necessary to Secure Complete Solution*

(1)	10 cc. of 0.6 M $AgNO_3$	10.3
(2)	10 cc. of 0.6 M $AgNO_3$ plus 10 cc. of 0.6 M NaOH	16.8
(3)	10 cc. of 0.6 M $AgNO_3$ plus 15 cc. of 1.2 M NH_3 plus 10 cc. of 0.6 M NaOH (i. e. reverse order)	1.7 = total of 16.7

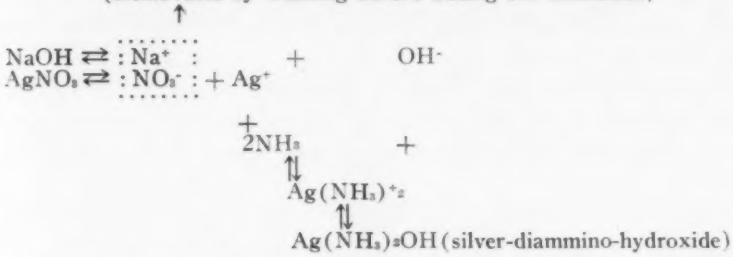
In the present case, the effect of the added ammonia is almost exclusively on the silver ion concentration and not on the hydroxyl ion concentration, since the presence of the strong base depresses the dissociation of the ammonium hydroxide and renders its contribution to the final hydroxyl concentration insignificant. Furthermore, the same amount of ammonia is required and the final solution is the same if the procedure is modified by first adding the alkali to silver nitrate and then treating with ammonia, which is the more usual procedure in histologic laboratories.

The strong alkalinity of a solution of equivalent amounts of silver nitrate and sodium hydroxide in ammonia is not dependent on the presence of an excess of sodium hydroxide over that which is exactly equivalent to the initial amount of silver nitrate. It is due to the fact

that silver diammino-hydroxide, which is formed in the reaction, is almost as strong a base as sodium hydroxide itself. The situation is represented in formula 2.

Formula 2

(Removable by washing before adding the ammonia.)



It is evident from formula 2 that if no excess of soldium hydroxide has been used, washing away the soluble sodium nitrate before adding the ammonia cannot appreciably affect the hydroxyl ion concentration of the final solution, ,since sodium hydroxide and silver-diammino-hydroxide are of comparable strength as bases. If, on the other hand, less than one equivalent of sodium hydroxide is used, there will be a lower hydroxyl concentration, and less ammonia will be needed. With an excess of sodium hydroxide the reverse will be true (table 2). In the latter case, moreover, washing the precipitate will actually wash away a certain amount of the excess sodium hydroxide, and so diminish the amount of ammonia required for solution after the washing. This is seen, in table 3, to be the essential difference between the Bielschowsky and the Cajal methods of preparing the solutions, in both of which a large excess of sodium hydroxide is used, but in the latter of which the precipitate is washed five or six times while in the former it is not washed at all. It is also evident from table 3 that complete removal of the excess base is not achieved even by ten washings of the precipitate, as there is still necessary a much larger amount of ammonia than is needed for the same amount of silver when only one equivalent of sodium hydroxide is used in the first place.

The actual hydroxyl ion concentrations of these solutions can be calculated from the amount of ammonia required to prepare them. These calculations are presented in the full discussion of these solutions which will shortly be published by one of us (D. D.).

With Sodium Carbonate and Ammonia ("Ammoniacal Silver Carbonate").—Before considering the nature of the ammoniacal silver carbonate or of ammoniacal silver nitrate plus sodium carbonate, the foregoing discussion may first be summarized as follows:

In ammoniacal silver nitrate solution there are present, as a result of dissociation of the complex ion, definite and significant concentrations of

silver ion, ammonia, and hydroxyl ion; the product of silver and hydroxyl ion concentrations, however, never exceeding the solubility product of silver hydroxide. If either the silver or the hydroxyl ion concentration is increased, by adding silver nitrate on the one hand or sodium hydroxide on the other, then silver hydroxide will be precipitated. In both cases, subsequent addition of a definite excess of ammonia will redissolve the precipitate.

If, however, a substance is added to ammoniacal silver nitrate which increases neither the silver nor the hydroxyl ion concentrations, and the ions of which form with silver ion no salt which is less soluble than

TABLE 2.—*Cubic Centimeters of 1.2 Molar Ammonia Necessary to Secure Complete Solution of the Precipitate*

(1)	10 cc. of 0.6 M $AgNO_3$	10.3
(2)	10 cc. of 0.6 M $AgNO_3$ plus 10 cc. of 0.6 M NaOH with no washing of the precipitate	16.8
(3)	10 cc. of 0.6 M $AgNO_3$ plus 10 cc. of 0.6 M NaOH with 8 washings of the precipitate	16.7
(4)	10 cc. of 0.6 M $AgNO_3$ plus 5 cc. of 0.6 M NaOH	15.2-15.6
(5)	10 cc. of 0.6 M $AgNO_3$ plus 20 cc. of 0.6 M NaOH	21.1

TABLE 3.—*Cubic Centimeter of 1.2 Molar Ammonia Necessary to Secure Complete Solution* *

(1)	Bielschowsky Method 10 cc. of 10 per cent $AgNO_3$ plus 12 drops of 40 per cent NaOH with no washing of the precipitate	22
(2)	Cajal Method 10 cc. of 10 per cent $AgNO_3$ plus 12 drops of 40 per cent NaOH with 10 washings of the precipitate	19.5

* If concentrated ammonia is used, these differences are too small to be demonstrated, representing less than one drop of the solution usually used in these methods.

silver hydroxide, then no precipitate will be formed and no further excess of ammonia will be required. Sodium carbonate is of this nature, since its hydroxyl concentration is less than that already existing in the ammoniacal solution, and since the silver carbonate which might be formed by combination of its acidic ion (CO_3^{--}) is more soluble than silver hydroxide. Hence the addition of sodium carbonate to ammoniacal silver nitrate does not produce precipitation; or, in other words, the precipitate produced by adding sodium carbonate to silver nitrate solution requires no more ammonia for re-solution than does silver nitrate itself. Washing the silver carbonate precipitate before adding ammonia does not have any effect on the final solution obtained, since here, too, the soluble sodium nitrate which would otherwise be present is of no consequence.

Although the actual concentration of hydroxyl ions is not altered, it is obvious that the addition of carbonate to the solution of silver in ammonia provides the final solution with a large amount of buffer. As a result, its titratable alkali is relatively high; that is, it will require a much larger amount of acid to change its hydroxyl ion concentration than that of a solution of ammoniacal silver nitrate.

TABLE 4.—*Cubic Centimeters of 1.2 Molar Ammonia Necessary to Secure Complete Solution of the Precipitate*

(1)	10 cc. of 0.6 M $AgNO_3$	10.3
(2)	10 cc. of 0.6 M $AgNO_3$ plus 10 cc. of 0.3 m Na_2CO_3 with no washings of the precipitate	10.4
(3)	10 cc. of 0.6 M $AgNO_3$ plus 10 cc. of 0.3 M Na_2CO_3 with 6 washings of the precipitate	9.8*
(4)	10 cc. of 0.6 M $AgNO_3$ plus 20 cc. of 0.3 M Na_2CO_3	10.4
(5)	Hortega Silver Method 10 cc. of 10 per cent $AgNO_3$ plus 30–40 cc. of 5 per cent Na_2CO_3	10.4

* This diminution of the amount of ammonia needed is due to the fact that the silver carbonate is soluble, so that every time the precipitate is washed a perceptible amount of the silver salt goes into solution and is lost. That this is true is shown by the fact that each decanted washing fluid gives a positive test for silver even when centrifugalized to rid it of finely divided particles of the precipitate itself. The silver lost in this way lessened, of course, the amount of ammonia needed for dissolving the precipitate which remained. This is true of silver hydroxide as well; but to a much slighter extent because silver hydroxide is much less soluble in water than is silver carbonate.

TABLE 5.—*Titration of Relative Amounts of Reserve Alkalinity of Ammoniacal Silver Solutions, with 0.12 Molar Nitric Acid*

(Silver solution, 10 cc.; thymol blue, 4 drops; titrated to p_H 8.4–8.6 *)

		Cc. of 0.12 M HNO_3
(1)	10 cc. of 0.6 M $AgNO_3$ plus 10 cc. of 0.6 M NaOH (precipitate not washed) NH_3 to complete solution (16.8 cc. of 1.2 M) Diluted to 50 cc. total volume	20.5
(2)	The same, except that the precipitate is washed before adding ammonia	20
(3)	10 cc. of 0.6 M $AgNO_3$ plus 10 cc. of 0.3 M Na_2CO_3 (precipitate not washed) NH_3 to complete solution (10.4 cc. of 1.2 M) Diluted to 50 cc. total volume	7.1*
(4)	The same, except that the precipitate is washed before adding the NH_3	6.9*
(5)	10 cc. of 0.6 M $AgNO_3$ plus NH_3 to complete solution (10.3 cc. of 1.2 M) Diluted to 50 cc. total volume	2

* Despite the formation of a cloudy white precipitate in the carbonate solutions, these end points are approximately correct.

A rough comparison of the titratable alkalinity of solutions of silver nitrate in ammonia alone, in sodium hydroxide and ammonia and in sodium carbonate (Na_2CO_3) and ammonia is presented in table 5. With thymol blue as indicator, an arbitrary end point at about p_H 8.4 to 8.6 was taken; and to 10 cc. of the solution tested, 0.12 molar nitric acid was added until the alkalinity of the solution was reduced to this point. At

this p_H the color of the thymol blue indicator changes from mauve to yellow. While not absolutely sharp, the end point is clearly recognizable.

It will be seen later that the high buffer content of the ammoniacal silver carbonate solution affects its activity in the same direction as does the high hydroxyl ion content of the ammoniacal silver solution which is made with sodium hydroxide, but to a less extreme degree.

We may summarize, then, certain essential facts about the chemistry of these solutions, as follows:

1. To dissolve silver nitrate, more ammonia is needed than that which is calculated from the structure of the ammoniacal silver cation which is formed.

2. If silver nitrate plus an exact chemical equivalent of sodium hydroxide is used, still more ammonia is required. This is due to the high hydroxyl ion concentration of the resulting solution; which, in turn, depends not on the presence of excess sodium hydroxide but on the fact that the silver diammino-hydroxide is itself a strong base.

3. The addition of one chemical equivalent of sodium carbonate to silver nitrate does not, on the other hand, make necessary the use of any more ammonia than with the silver nitrate alone. It is evident, therefore, that solutions of ammoniacal silver nitrate and ammoniacal silver carbonate have approximately identical hydroxyl ion concentrations—and that this hydroxyl ion concentration is much less than that of a solution of ammoniacal silver hydroxide.

4. Between solutions of ammoniacal silver nitrate and ammoniacal silver carbonate there remains, however, the important difference that the solution of ammoniacal silver carbonate is very heavily buffered, while the other is only weakly buffered.

THE BEHAVIOR OF SILVER SOLUTIONS TOWARD TISSUES AND IN FORMALDEHYDE REDUCTION

It is readily demonstrated that the three ammoniacal silver solutions show great differences in activity and stability. Of the three, the ammoniacal silver nitrate is the most stable, least sensitive to light, least readily reduced, and least easily combines with tissues. The ammoniacal silver hydroxide solution is at the other extreme in all of these characteristics; the carbonate exhibits properties which lie between these two extremes. These facts are brought out quantitatively in table 6.

The precipitate which forms slowly under the action of formaldehyde on ammoniacal silver nitrate solutions is a slowly spreading cloud of finely divided gray dust which settles gradually and forms on the glass dish a delicate mirror surface. The solution of ammoniacal silver carbonate precipitates more promptly as a darker and heavier cloud and

forms more extensive mirror deposits. The solution of ammoniacal silver hydroxide precipitates almost instantaneously as a heavy black cloud and gives inconstant mirror surfaces on the walls of the container.

If these same solutions are heated carefully and slowly to a temperature of 50 C., in the presence of frozen sections of a brain which has been fixed in a solution of formaldehyde-ammonium-bromide (as for the

TABLE 6.—*Sensitivity to Formaldehyde Reduction and Reactivity with Tissues* *

Solutions Tested	Latent Period Before Appearance of Reduced Silver Precipitate in Formaldehyde Solutions of Different Strengths				Latent Period Before Tissue Sections Show Macroscopic Staining
	0.5 Percentage	0.05 Percentage	0.01 Percentage	0.005 Percentage	
$AgNO_3$ plus NH_3 alone.....	10-15 sec.	90 sec.	200 sec.+	6 min.+	35-45 min.
$AgNO_3$ plus equivalent NaOH plus NH_3	Instantaneous	2-3 sec.	12-15 sec.	35-40 sec.	4-6 min.
$AgNO_3$ plus equivalent Na_2CO_3 plus NH_3	4 sec.	30-40 sec.	110-125 sec.	250 sec.	15-20 min.
$AgNO_3$ plus equivalent NaOH with washing of the precipitate	Instantaneous	2-3 sec.	12-18 sec.	38-40 sec.	4-6 min.
Idem but without washing precipitate	Instantaneous	2-3 sec.	12-15 sec.	35-40 sec.	4-6 min.
$AgNO_3$ plus equivalent Na_2CO_3 with washing of the precipitate	4 sec.	35-40 sec.	115-155 sec.	240-260 sec.	15-20 min.
Idem but without washing precipitate	4 sec,	30-40 sec.	110-125 sec.	250 sec.	15-20 min.
$AgNO_3$ plus ½ equivalent NaOH	Instantaneous	4.5-5 sec.	20-30 sec.	45-55 sec.	7-9 min.
$AgNO_3$ plus 1 equivalent NaOH	Instantaneous	2-3 sec.	12-15 sec.	35-40 sec.	4-6 min.
$AgNO_3$ plus 2 equivalent NaOH	Instantaneous	1 sec.	5-8 sec.	12-18 sec.	3-5 min.
$AgNO_3$ plus 1 equivalent Na_2CO_3	4 sec.	30-40 sec.	110-125 sec.	250 sec.	15-20 min.
$AgNO_3$ plus 2 equivalent Na_2CO_3	4 sec.	25-35 sec.	100-115 sec.	.....	15-20 min.
Bielschowsky silver method.....	Instantaneous	1.5-2.0 sec.	6-8 sec.	15-25 sec.	3-5 min.
Cajal silver method (i. e., Bielschowsky silver method with washing of precipitate)	Instantaneous	2.5-3.0 sec.	8-10 sec.	25-35 sec.	5-6 min.
Hortega silver method.....	3 sec.	20-30 sec.	80-105 sec.	200-240 sec.	13-19 min.

* The data on formaldehyde reduction were obtained by blowing 0.3 cc. of the silver solution suddenly and vigorously into a small glass dish containing 2 cc. of the formaldehyde solution, and timing with a stop-watch until the moment of appearance of a diffuse cloud. The range of values given for any one reduction expresses both the observational error and the deviations of several observations.

The data on staining of tissues were obtained on the washed sections from a brain which had been fixed in a solution of formaldehyde-ammonium-bromide and cut on the freezing microtome. In each test, several such sections were placed in a covered glass dish containing 7 cc. of the silver solution to be tested, and with continual stirring were warmed gently over a pilot flame from a bunsen burner. By avoiding draughts and keeping the height of the pilot flame constant, a quite slow and unvarying rate of warming was maintained; when a temperature of about 50 C. was reached, the temperature was held at that point until the sections were stained to match a light tobacco-brown color standard. (Histologic studies of much of this material have also been made. The later steps of washing and reduction, however, introduce new questions, so that an analysis of the full staining process lies beyond the scope of the present paper and must be reserved for a later report.)

glia stains of Cajal or Del Rio-Hortega), similar differences are seen. The solution of ammoniacal silver nitrate will stain the sections little or not at all, requiring from thirty-five to forty-five minutes of heating for whatever staining does occur, and in subsequent formaldehyde reduction giving largely a superficial precipitate and little union with the tissue

elements. The carbonate begins to stain the sections within five or ten minutes, giving to them a rapidly deepening tobacco tint before the solution itself begins to exhibit any discoloration, and attaining an optimum depth of color in the tissues while the solution still remains pale amber. In subsequent reduction by formaldehyde the tissue elements may show beautiful stains with no diffuse precipitate. The hydroxide is even more rapid in its action. It begins to combine with the sections almost at once, coloring them brown, but almost as quickly the solution darkens and a precipitate starts to form.

THE CORRELATION BETWEEN THE DIFFERENCES IN ACTIVITY AND IN ALKALINITY OF THE SILVER SOLUTIONS

It is well known that silver nitrate cannot be reduced in an acid solution and is readily reducible in alkali. The theoretical basis for this involves considerations which lie beyond the scope of the present study. But the observations presented here indicate that the same general relationship holds true for the ammoniacal silver solutions; namely, that the more strongly alkaline such a solution is, the more sensitive it becomes to reducing influences. This explains the extreme sensitivity of the solution of ammoniacal silver hydroxide.

The effect of the addition of carbonates to a solution of ammoniacal silver nitrate is explicable on the same basis. Not only are almost all formaldehyde solutions acid,[10] but in the reaction itself in which silver is reduced, formaldehyde is oxidized to formic acid, and nitric acid is produced. The presence of these acids blocks the reduction of the ammoniacal silver nitrate solution. The addition of carbonates to this solution, on the other hand, buffers it against the action of the acids, stabilizes its hydroxyl ion concentration, and thus assists the reduction.

The same holds true for spontaneous reduction of the silver solutions, only to a less striking extent. In this case, the only acid involved is the production of nitric acid in the silver solution as the reduction occurs. If this is not absorbed by a buffer, further reduction is lessened. If there is some alkaline buffer salt present, the effect of the nitric acid is blocked.

The nature of the reaction between formaldehyde-fixed brain substance and the silver salts is still so obscure that theoretical treatment is not possible at present. The observations presented in this study show, however, that the reactions of the ammoniacal silver solutions with weak formaldehyde solutions and their reactions with tissues run parallel courses; which suggests that, in some way, the same fundamental laws must apply to both.

10. Even when made up from so-called "neutral" formaldehyde, absorption of carbon dioxide and spontaneous oxidation to significant amounts of formic acid rapidly produce a p_H which ranges from 3 to 5.

THE CHOICE AND PREPARATION OF THE AMMONIACAL SILVER SOLUTIONS

It has been shown that the three chief methods of preparing ammoniacal silver salts that have been recommended by histologists yield staining solutions which in their fundamental physicochemical properties are alike, but which differ in sensitivity, rate, intensity and stability. These differences have an important bearing on the utility of the various solutions.

For practical purposes, the ammoniacal silver nitrate solution is only rarely valuable. It can be used occasionally instead of silver nitrate as the preliminary bath for a Bielschowsky or Cajal stain for neurofibrils. The sections may then be passed *without washing* into a solution of ammoniacal silver carbonate or ammoniacal silver hydroxide, because the ammoniacal silver nitrate will not give a precipitate in these solutions as does silver nitrate. This eliminates the washing between the two silver solutions which is necessary in the usual procedure, and which results, at times, in incomplete impregnations. If ammoniacal silver nitrate is used, the initial bath must be much shorter than the usual bath in silver nitrate.

The ammoniacal silver hydroxide and the ammoniacal silver carbonate can be used interchangeably if the differences in the sensitivity of the two solutions are compensated for by varying their concentrations, the duration of the bath, the heat used, the concentration of the reducing agent, etc. As already indicated, however, the carbonate solution has the double advantage that its hydroxyl ion concentration is not high enough to render it as unstable and as oversensitive as the ammoniacal silver hydroxide, while the presence of the buffer salts makes it possible for the reduction of the carbonate solution to go forward steadily despite the accumulation of acids in the reaction. For this reason, it is easier with the carbonate solution to avoid overstaining and the formation of superficial precipitates.

Preparation of these solutions with reasonable accuracy is so easily achieved that it seems unnecessary to use any longer the traditional inaccurate methods of histologists. The use of more exact and equally simple procedures has the great advantage that it makes it possible for the histologist to turn to the chemist for assistance without having to retranslate all of his roughly prepared solutions into terms with which the chemist can work. For this reason, simple methods of exact preparation of these solutions are outlined:

Silver Nitrate.—As already explained, because it is approximately of the same strength as that customarily used, a 0.6 molar solution of silver nitrate is recommended. ($AgNO_3$, molecular weight $170 \times 0.6 = 102$ Gm. per liter, or 10.2 Gm. per hundred cubic centimeters). This can be weighed out with an accuracy of 0.1 Gm. on an ordinary chemical balance on filter paper, and does not require

a glass-inclosed quantitative balance. It should be transferred to a glass funnel in the mouth of a hundred cubic centimeter volumetric flask. (A graduated cylinder is not sufficiently accurate for this.) By slowly pouring distilled water through the silver nitrate, it can be washed into the flask; after solution is complete, the flask can be filled to the one hundred cubic centimeter mark, thoroughly shaken, and the contents can be transferred to a dark bottle.

Ammonia.—The formula of the ion, $Ag(NH_3)_2^+$ makes it desirable to use a solution of ammonia of twice the molar concentration of the silver nitrate, i.e., 1.2 molar.

(*a*) The molecular weight of ammonia is 17.

1.2 molar $= 17 \times 1.2 = 20.4$ Gm. per liter, or 2.04 Gm. per hundred cubic centimeters.

(*b*) A usual strength of the commercial stock solutions is 28 per cent at a specific gravity of 0.90. (The data are usually on the bottle or can be secured from the manufacturer.) The stock solution used in the present investigation contained, therefore, $0.28 \times 0.90 = 0.252$ Gm. ammonia per cubic centimeter.

(*c*) $\frac{2.04}{0.252} = 8.09$ cc. of the concentrated stock solution; diluted to a volume of one hundred cubic centimeters with distilled water, gives a final solution of 1.2 molar.

The concentrated stock solution should be measured in an accurate ten cubic centimeter pipet, or in a microburet, and after transferring to a one hundred cubic centimeter volumetric flask should be diluted to the one hundred cubic centimeter mark.

Sodium hydroxide.—The equation, $AgNO_3 + NaOH = AgOH + NaNO_3$, makes it evident that a 0.6 molar solution of sodium hydroxide will be chemically equivalent to 0.6 molar silver nitrate. This can best be prepared in the following way:

A strong stock solution of sodium hydroxide is prepared containing 50 Gm. of sodium hydroxide dissolved in one hundred cubic centimeters of water. Actually, however, even dry sticks of chemically pure sodium hydroxide contain significant amounts of carbonate. The amount of this contamination is indicated on the label of the bottle, and a corresponding excess over 50 Gm. of the commercial sodium hydroxide must be weighed out to allow for this. After the solution has cooled, it should be filtered through glass wool or centrifugalized, in order to rid it of the carbonates which are insoluble in alkali of this concentration. The solution should then be stored in a paraffined flask and well stoppered. It will then be stable and can be used repeatedly.

Such a solution of sodium hydroxide, 50 per cent by weight, has a density of 1.53. Each cubic centimeter contains, therefore, $1.53 \times 0.50 = 0.77$ Gm. of sodium hydroxide.

The molecular weight of sodium hydroxide is 40. A 0.6 molar solution will contain, therefore, $0.6 \times 40 = 24.0$ Gm. per liter, or 2.4 Gm. per hundred cubic centimeters. Hence, to prepare from the concentrated stock solution, a solution of 0.6 molar sodium hydroxide (which contains 0.024 Gm. per cubic centimeter), it is necessary to take of the stock solution $\frac{0.024}{0.77} = 0.0312$, or 3.1 cc., and dilute to a total volume of one hundred cubic centimeters.

Once the concentrated stock solution has been prepared, this is the easiest and most accurate method of preparing the sodium hydroxide solution.

Sodium Carbonate.—$2AgNO_3+Na_2CO_3=Ag_2CO_3+2NaNO_3$. Therefore, a 0.3 molar solution of sodium carbonate will be equivalent to a 0.6 molar silver nitrate.

Sodium carbonate is obtained in three forms: as the dry compound, the molecular weight of which is 106; as sodium carbonate monohydrate ($Na_2CO_3.H_2O$), with a molecular weight of 124, as sodium carbonate decahydrate ($Na_2CO_3.10H_2O$), with a molecular weight of 286. Either the dry compound or the decahydrate may be used, as they are relatively stable. If the dry compound is used, it should be purchased in small bottles and should be kept tightly stoppered. The top layer of the salt should always be scraped off and discarded before weighing out a samples, as it will absorb moisture from the atmosphere and the hydrated compound will contain less actual salt in the amount weighed than has been calculated.

For the dry salt, one should use: $0.3\times106=31.8$ Gm. per liter, or 3.2 Gm. per hundred cubic centimeters.

For the decahydrate: $0.3\times286=85.8$ Gm. per liter, or 8.6 Gm. per hundred cubic centimeters.

The presence of a certain amount of bicarbonate in the sample of carbonate will not introduce an inaccuracy of sufficient magnitude to require any corrections. These compounds should be dissolved gradually, allowed to cool, made up to final volume in a one hundred cubic centimeter volumetric flask, and transferred to a paraffined flask.

In using the solutions which are prepared in the manner described, it is possible to secure exact equivalents merely by taking equal volumes. If a ten cubic centimeter pipet, graduated to 0.1 cc. is used for the silver nitrate, the sodium hydroxide and the carbonate, and if either a similar pipet or else a fifty cubic centimeter buret similarly calibrated is used for the ammonia, it is possible to keep exact records of the composition of the solutions. The ionic composition of such solutions can then be calculated or determined, so that accurate information will become available for the standardization of these methods.

The most desirable method of preparing the staining solutions is as follows:

1. Use a fifty cubic centimeter or one hundred cubic centimeter glass-stoppered volumetric flask, depending on the concentration of the solution which is finally desired.

2. Into this flask introduce 10 cc. of the 0.6 molar silver nitrate with a ten cubic centimeter pipet.

3. Add ammonia from the buret until complete solution of the silver has occurred. Add ammonia rapidly at first, but shake vigorously between additions toward the end point.

4. Add 10 cc. of the 0.6 molar sodium hydroxide or else 10 cc. of the 0.3 molar sodium carbonate. If the carbonate is used, no more ammonia will be needed. If the sodium hydroxide is used, more ammonia will be necessary. After this procedure has been carried out once or twice, however, it will be possible to add enough ammonia in the first place to prevent the formation of any precipitate with the sodium hydroxide.

There is a definite advantage in adding the ammonia before the sodium hydroxide in sufficient quantity precisely to prevent the formation of any precipitate by the strong alkali. The precipitated silver oxide, in the presence of a strong base, tends to reduce with the deposition of metallic silver. This metallic silver cannot be returned to solution by the addition of ammonia, and the

presence of these granules mixed with the precipitate of silver oxide obscures the end point and leads to the use of a greater excess of ammonia than is necessary. If enough ammonia is used to begin with, there need never be any precipitate formed in the presence of the strong alkali.

Finally, the solution is diluted by the addition of distilled water to the volume desired.

SUMMARY

1. The ammoniacal silver solution which is prepared from silver nitrate and ammonia alone is spoken of as the solution of "ammoniacal silver nitrate," with sodium carbonate and ammonia as "ammoniacal silver carbonate," and with sodium hydroxide and ammonia as "ammoniacal silver hydroxide."

2. The ammoniacal silver ion which is formed in the three methods used for preparing silver staining solutions is constant in formula, $Ag(NH_3)_2^+$.

3. The activity of this ion is, however, variable, depending on the ions with which it is associated in solution. The variation of activity is not qualitative, but solely one of sensitivity, stability, rate and intensity.

4. It was found that the amount of ammonia required to cause complete solution of the silver compound varied with the hydroxyl ion concentration of the solution, and that the ammoniacal silver nitrate and the ammoniacal silver carbonate required practically the same amount of ammonia, while the ammoniacal silver hydroxide required much more. The ammoniacal silver nitrate and carbonate solutions have, therefore, practically identical hydroxyl ion concentrations, while that of the ammoniacal silver hydroxide solution is much higher.

5. The ammoniacal silver carbonate solution differs from the ammoniacal silver nitrate, however, in having a much higher titratable or reserve alkalinity as shown by titration with acid. This is due to the buffering action of the carbonate salts.

6. The differences in activity of the ammoniacal silver solutions are shown to correlate with these differences in hydroxyl ion concentration and in titratable alkalinity.

7. Consequently, of the three solutions the ammoniacal silver hydroxide, because of its extremely high hydroxyl ion concentration, is the most unstable—that is, it reduces most readily under the action of light or of formaldehyde, and combines most rapidly with tissue elements. The ammoniacal silver nitrate solution is, on the contrary, most "stable" in all of these respects, because its hydroxyl ion concentration is lower, and because the presence of acid in the formaldehyde and the production of acid in the process of reduction arrests the reduction itself. The ammoniacal silver carbonate is also less unstable than the hydroxide because, like the ammoniacal silver nitrate, its hydroxyl ion concentration

is lower; but, unlike the nitrate solution, it is readily reduced because the carbonate salts buffer it effectively against the inhibiting action of the acids.

The ammoniacal silver carbonate solution is thus seen to occupy an optimal position, intermediate between the other two.

8. The ammoniacal silver nitrate solution is only rarely useful. Both the hydroxide and the carbonate solutions, on the other hand, have many uses. They are not interchangeable, however, without taking into account the differences in speed and sensitivity of their action. If these differences are compensated for by appropriate adjustment of other steps (such as the concentration, duration, and temperature of the silver baths, and the strength of the reducing agent), the hydroxide and the carbonate solutions can be made to achieve approximately the same results.

9. For most purposes, the ammoniacal silver carbonate solution, because of its greater stability and its somewhat slower action, is more easily handled; certainly, for those who are relatively inexperienced with these methods, it will yield satisfactory stains more readily than the ammoniacal silver hydroxide.

10. Simple and yet accurate methods for preparing these solutions are described, to take the place of the unstandardized methods in customary use.

11. It has been shown that washing the precipitate, after using an excess of sodium hydroxide, only partially removes the excess base, making it preferable to use only equivalent amounts of reagents in the first place.

Clinical and Occasional Notes

METASTATIC ABSCESSES OF THE BRAIN OF PULMONARY ORIGIN: A REPORT OF TWO CASES*

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This paper contains a report of two cases of metastatic abscess of the brain from the neurosurgical service of the University of Pennsylvania Hospital. The sequence of events in the two cases was exactly similar and rather unusual; namely, tonsillectomy, abscess of the lung, and abscess of the brain, with recovery in the patient with solitary cerebral abscess and death in the patient with multiple abscesses.

Abscesses of the brain may arise from an adjacent area of suppuration, such as disease of the middle ear, infection of the sinuses and traumatic cranial lesions; they may be secondary to a retrograde cerebral thrombophlebitis, or they may be metastatic or hematogenous in origin. The last group is considerably smaller than the preceding two and it has been estimated (Eagleton) that about 12 per cent of the metastatic abscesses are of pulmonary origin.

Probably the largest collection of reports of abscess of the brain secondary to disease of the lung is that published by Schorstein.[1] In this series of sixty-nine cases, the etiologic factors were:

Bronchiectasis in thirty-eight, or 55 per cent; empyema in fifteen, or 22 per cent; gangrene of the lung in six, or 9 per cent; tuberculosis in three, or 4.5 per cent; acute pneumonia in two, or 3 per cent; abscess of the lung in two, or 3 per cent, and fetid bronchitis and empyema in two, or 3 per cent.

Why is abscess of the brain so much more common after bronchiectasis than after abscess of the lung? Surely these figures do not represent the relative frequency of the two conditions. In analyzing sixty-three cases of bronchiectasis which came to autopsy, Schorstein found that death was due to abscess of the brain in thirteen cases, or 20 per cent. Two factors may help to explain this situation: the chronicity of the course of bronchiectasis as compared with abscess of the lung and the extreme frequency of nasal sinusitis as a complicating factor in bronchiectasis. It has been suggested[2] that the sinuses should be carefully investigated in all cases of abscess of the brain that supposedly are metastatic from bronchiectasis.

Another question is frequently asked: Why is abscess of the brain so common after suppurative pulmonary disease and so rare in ulcerative endocarditis? In the latter cases there is always a blood stream infection with showers of emboli thrown off from the valves of the heart; metastatic abscesses are frequently found in other organs of the body but only rarely in the brain. This may perhaps be explained by the normal resistance of the brain tissue to suppuration. This protective mechanism of the brain may be upset by the circulatory changes induced by the paroxysms of coughing so frequent in suppurative pulmonary

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* Read at a meeting of the Philadelphia Neurological Society, April 22, 1927.

1. Schorstein: Abscess of the Brain in Association with Pulmonary Disease, Lancet **2**:842 (Sept. 18) 1909.

2. Adams, James: Connection of Brain Abscess with Bronchiectasis, J. Laryng. & Otol. **41**:93 (Feb.) 1926.

disease. Coughing or straining results in a positive intrathoracic pressure which forces the venous blood out of the chest, as shown by the dilated jugular veins during these acts. Thus there is a damming back of venous blood into the cerebral veins. At the same time there is a change in the arterial circulation. As a result of decreased venous return to the heart, occasioned by the positive intrathoracic pressure, there must also be a decreased arterial output from the heart. This must cause a transient ischemia of the brain. That this actually takes place is demonstrated by the fact that transient loss of consciousness frequently occurs in vital capacity tests when the subject is forcibly expiring against resistance. These two factors, namely, venous engorgement and arterial ischemia as a result of coughing, must render the lodging of an embolus easier and at the same time must temporarily lower the normal resistance of the cerebral tissues and give the implanted organisms a better chance to grow.

Eagleton[3] explained abscess of the brain secondary to suppuration in the lungs as primarily of thrombotic or venous origin, the brain being peculiarly susceptible to such a portal of entry, whereas, abscess resulting from suppurative endocarditis may be primarily embolic, and against this the brain may possess a resistance not present in such organs as the spleen and the kidneys. Eagleton substantiates his view by the experiments of Arnold[4] who demonstrated that on injection of bran into the large veins of the neck in cases in which interference with the normal intrathoracic negative pressure had occurred, particles of the bran are found in the opposite venous sinus. According to his experiment, the venous circulation from the head to the heart is reversed when a positive intrathoracic pressure is encountered. But the only venous pathway by which a pulmonary embolus may be carried to the brain is by means of the small bronchial and pulmonary veins which empty into the azygos and hemiazygos veins, and thence into the superior vena cava; from there, provided the venous circulation is reversed, they may be carried by the innominates to the internal jugulars, back through the sinuses into the cerebral veins. But the azygos veins with the hemiazygos on the left side carry only a small portion of the return blood from the lungs, the major portion being carried by the large pulmonary veins into the left auricle; from there to the left ventricle and thus into the aorta. Therefore, any embolus which leaves the lungs by means of a tributary to one of the large pulmonary veins must perforce constitute an arterial embolus.

As regards the relative frequency of solitary and multiple metastatic abscesses of the brain, Schorstein[1] found that in fifty-one cases of abscess of the brain secondary to disease of the lung, 62 per cent were single and 38 per cent multiple. Eagleton stated that 45 per cent of metastatic abscesses of the brain are solitary and that in pulmonary disease the left side of the brain is the site of metastatic abscesses three times more commonly than the right; the frontal lobe is especially apt to be the seat of the abscess. The cerebellum is infrequently attacked.

REPORT OF CASES

Case 1.—*History.*—L. K., a man, aged 25, was admitted to the bronchoscopic service of the University Hospital, March 29, 1926, under the care of Dr. Chevalier Jackson, complaining of cough and expectoration. On May 1, 1925, the patient, while in another hospital, had tonsillectomy performed under ether anesthesia. Four days later he developed pain in the right side of the chest and fever. Ten

3. Eagleton, Wells P.: Brain Abscess, New York, The Macmillan Company, 1922.

4. Arnold, J.: Ueber rückläufigen Transport, Arch. f. path. Anat. **124**:385, 1891.

days later he began to cough up purulent material. A diagnosis of abscess of the lung was made, and he was treated by postural drainage with little improvement. Hemoptysis developed. For a month prior to admission, he complained of headaches brought on by slight exertion.

Examination.—On admission, the patient had irregular fever, and the leukocyte count was 17,500. The diagnosis of abscess of the right middle lobe of the lung was confirmed by roentgen-ray and by bronchoscopic examination. The patient was expectorating pus, frequently mixed with blood.

On April 4, 1926, he was transferred to the medical service under the care of Dr. Alfred Stengel, as bronchoscopic drainage was considered inadvisable in the presence of hemoptysis.

On April 14, it was noted that the temperature and pulse were subnormal.

On April 16, he complained of headache and was somnolent. The leukocyte count had dropped to 6,400. The following day he developed tenderness in the left frontal region and weakness of the right side of the face and arm. Speech

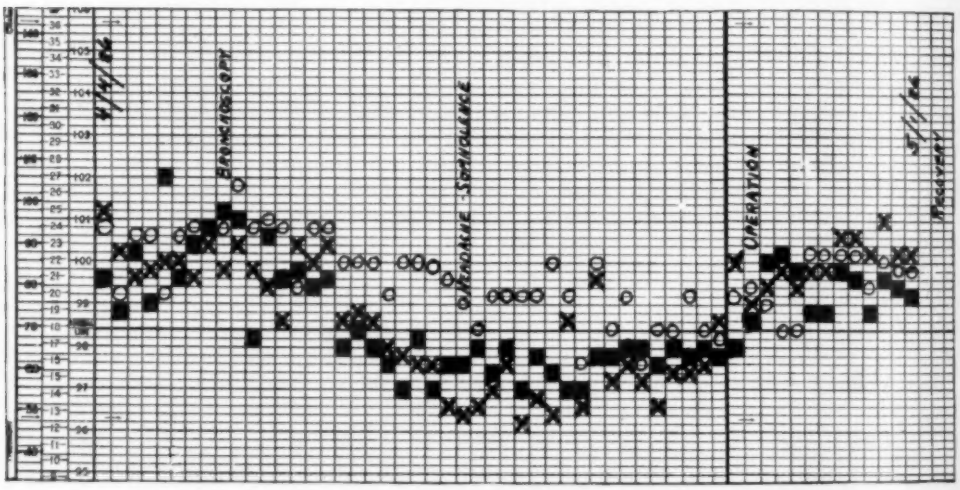

Chart 1 (case 1).—Temperature chart showing subnormal temperature and pulse and respiration rates occurring with the onset of symptoms. In this chart and chart 2, the black squares indicate the temperature; the X's, pulse rate and the circles, respiration rate.

was rather slow and hesitant. A diagnosis of abscess of the left frontal lobe was made, and the patient was transferred to the neurosurgical service.

Operation.—On April 26, 1926, the skull was perforated just in front of the lower end of the left fissure of Rolando and an opening made about the size of a half dollar. The dura was nicked and the site of the puncture bathed with iodine solution. A cannula was introduced inward and slightly forward; pus was encountered at a depth of from 3 to 4 cm. Rubber tube drainage was instituted. A culture of the pus revealed *Staphylococcus albus.*

Course.—The tube was removed at the end of four weeks, and convalescence was uneventful. The patient was discharged, May 31, 1926, by which time the wound had healed entirely and the patient was free from symptoms. He was readmitted to the University Hospital, July 27, 1926, on the service of Dr. E. L. Eliason and thoracotomy was performed with drainage of the abscess of the lung.

Convalescence was rapid, and the patient had remained in good health up to the time this paper was written.

CASE 2.—*History.*—F. L., a boy, aged 9, was admitted to the bronchoscopic service of the University Hospital on Nov. 28, 1926, under the care of Dr. Chevalier Jackson. Tonsillectomy and adenoidectomy under ether anesthesia had been performed in another hospital in July, 1926. Convalescence was rapid and complete. Three or four weeks after the operation, the patient developed a slight cough with fever and raised a little blood-streaked mucus. Cough and fever continued; in September, a roentgenogram revealed an abscess of the lung.

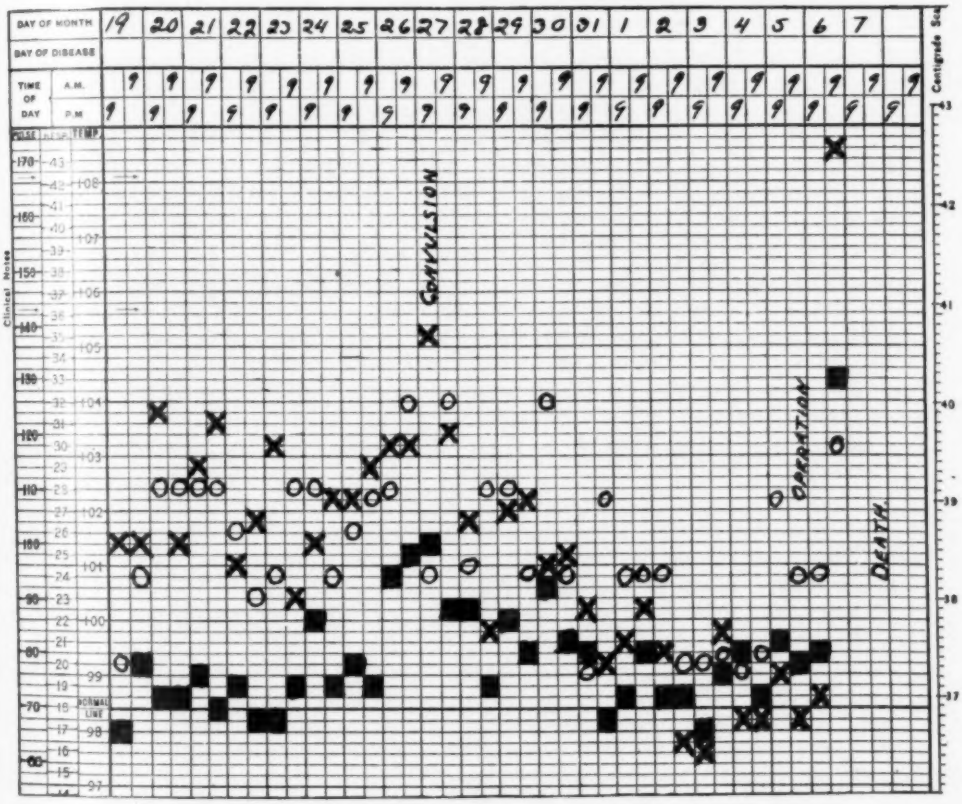

Chart 2 (case 2).—Temperature chart showing decline in temperature and pulse and respiration rates following onset of cerebral symptoms but not reaching the low level shown in case 1.

Examination.—On admission, the temperature was 100 F., the pulse rate was 120, and the respiration rate, 24. The white cells numbered 12,000. The patient was expectorating a considerable amount of foul smelling pus. A second roentgenogram of the chest revealed an abscess of the upper portion of the lower lobe of the right lung, and this was corroborated by bronchoscopic examination.

Course.—On Dec. 7, 1926, Dr. George Muller advised external drainage.

On Dec. 9, 1926, a first stage thoracotomy was performed; on December 14, the abscess of the lung was drained. Culture of the pus revealed a hemolytic streptococcus. Following the operation, convalescence was satisfactory and the

patient was about ready to be discharged, when on December 26, it was noted that the temperature, which had been rising for the past forty-eight hours, reached 101 F. The patient seemed to be in poor spirits and vomited his lunch. The white cell count was 17,300.

On December 27, the patient complained of headache in the morning and at 2 p. m. developed a convulsion affecting the right side of the face and the right arm and leg. On examination two hours later, there was a complete right hemiplegia and partial motor aphasia. Choking of the optic disks was not found. A diagnosis of cerebral embolus was made. The hemiplegia and aphasia cleared up completely within twenty-four hours.

During the succeeding nine days, the temperature and pulse and respiration rates gradually declined but the leukocyte count remained 19,000. Increasing vomiting, irritablity and somnolence occurred. The optic disks showed evidence of increasing intracranial pressure. Changes in the visual fields on hand field examination and other localizing signs were not present.

On Jan. 6, 1927, the child suddenly became more stuporous and developed a left hemiparesis and complete ophthalmoplegia. Rigidity of the neck and Kernig's sign were not present. Lumbar puncture revealed a pressure of 60 mm. of mercury, and the fluid contained 30 polymorphonuclears and 3 lymphocytes.

Operation.—A trephine opening was made over the junction of the left rolandic and sylvian fissures; a brain cannula was introduced in various directions, but pus was not encountered. Continuous drainage of the spinal fluid was instituted in the upper dorsal region because of the signs of meningitis. Improvement did not follow the operation, and the patient died the following day.

Necropsy.—Multiple cerebral abscesses and a meningitis of five or six days' duration were found. There was a large abscess in each occipital lobe, one in the right frontoparietal area and one in the left temporoparietal area. Culture of the pus revealed a hemolytic streptococcus.

COMMENT

These two cases are interesting for several reasons. The sequence of events—tonsillectomy, abscess of the lung and abscess of the brain—was exactly similar in the two cases. In both, abscess of the brain developed while the patient was under observation. The case in which the solitary abscess occurred shows that abscess of the brain may cause a subnormal temperature and pulse rate and a normal leukocyte count even in the presence of a suppurating pulmonary lesion which had previously caused fever and leukocytosis. The onset in the case in which multiple abscesses of the brain occurred was apoplectiform and in the case in which the solitary abscess occurred was insidious.

The prognosis of abscess of the brain of pulmonary origin, while grave, is not hopeless. Three instances of recovery are recorded in the literature by Roulland,[5] Seymour Barling[6] and Hurst.[7] The report of at least one case with the sequence of events as already described appears in the literature. Bassoe[8] reported a case in which the sequence of events was: tonsillectomy, abscess of the lung, abscess of the brain and death.

5. Roulland, Henri: Abcés métastatique du cerveau au cours d'une suppuration pleurale. Trepanation, drainage de l'abcés, guérison, Paris chirurg. **9**:613 (May) 1917.

6. Barling, Seymour: A Case of Cerebral Abscess Complicating Abscess of Lung, Lancet **1**:121 (Jan. 17) 1925.

7. Hurst, A. F.: A Case of Cerebral Abscess Complicating Empyema, Lancet **1**:605 (March 21) 1925.

8. Bassoe, Peter: M. Clin. N. Amer. **3**:1629 (May) 1920.

News and Comment

INTERNATIONAL NEUROLOGICAL CONGRESS

At the suggestion of the council of the American Neurological Association, letters have been sent to the leading neurologists throughout the world for a proposed International Neurological Congress to be held in 1931. The proposition has been greeted with enthusiasm, and favorable replies have been received from many countries. Further announcement of the place and date of the meeting, with the subjects for discussion and the organization of the congress, will be published later.

The American committee consists of the following physicians: Bernard Sachs, M.D., New York, chairman; Charles L. Dana, M.D., New York; Frederick Tilney, M.D., New York; Theodore H. Weisenburg, M.D., Philadelphia, and Henry Alsop Riley, M.D., New York, secretary.

BRITISH-AMERICAN NEUROLOGIC MEETING

The return meeting of the neurologic section of the Royal Society of Medicine and the American Neurological Association will be held in the United States in 1930. The British Medical Association will meet in Winnipeg, Canada, in that year.

Abstracts from Current Literature

GYRUS LIMBICUS ANTERIOR AND REGIO RETROSPLENIALIS (CORTEX HOLOPROTOPTYCHOS QUINQUESTRATIFICATUS): COMPARATIVE ARCHITECTONICS OF THESE AREAS IN ANIMAL AND MAN. MAXIMILIAN ROSE, J. f. Psychol. u. Neurol. **35**:65, 1927.

The chief characteristic of this type of holoprotoptych cortex is its division into five layers. It represents a transitional state between a holoprotoptych cortex consisting of two layers (formatio ammonis) and a seven layer cortex of the same kind (homogenetic cortex, isocortex euradiatus); it is therefore designated as a mesocortex. No cortex corresponding to it could be found in the lower vertebrates. It is first seen in mammals. The greater part of the embryonal lamina granularis primaria retains its definitely granular character in one portion of the cortex holoprotoptychos quinquestratificatus (mouse, dog, half-ape). In other mammals, on the other hand (rabbits, man), some of the cells of a part of this lamina, especially the part lying immediately below the lamina zonalis, is differentiated into small and middle-sized pyramidal cells, whereas the remaining part is granular. This type of cortex is, in most animals, situated dorsad to the caudal portion of the corpus callosum, chiefly in the region of the splenium. It is therefore designated as the regio retrosplenialis granularis. In another part of the cortex holoprotoptychos quinquestratificatus almost all cells of the embryonal lamina granularis primaria are differentiated into small and moderately large pyramidal cells. This type of cortex is principally situated dorsad to the anterior part of the corpus callosum; its chief characteristic is that during ontogenetic development a definite lamina granularis (IV) can be found. The anterior limbic area represents a cortex of this type (Brodmann's area 24). According to Vogt, this area shows in the myelo-architectonic picture the infraradiar type of cortex so that this entire region is designated the regio infradiata. Finally, the cortex holoprotoptychos quinquestratificatus contains in the region of the splenium one or more types of cortex which are developmentally almost identical with the regio infradiata. The cells of the second, third and fourth layers are throughout of pyramidal shape, and there is no lamina granularis (IV). In the myelo-architectonic picture this type of cortex is supraradiar. Owing to its location this region is called the regio retrosplenialis agranularis, in spite of the fact that genetically as well as architectonically it is close to the regio infraradiata. In the monotremes and *marsupialia* conditions are more primitive; here the regio infraradiata and regio retrosplenialis agranularis still represent a uniform field. Not until *Insectivora* and *Chiroptera* are reached do these two areas form distinct and separate regions.

The layers of all regions of the cortex holoprotoptychos quinquestratificatus show certain characteristics common to all these types of cortex. The lamina zonalis (I) is relatively wide in the entire cortex holoprotoptychos quinquestratificatus; the fifth layer (lamina ganglionaris) is also wide, and is in most cases subdivided into two layers.

The division into lobes cannot be regarded as the substratum for the architectonic divisions of the cerebral cortex. The lobes often are made up of areas that are architectonically as well as functionally heterogenous cortical regions.

Regio Infraradiata.—In *Ornithorhynchus* this region is on the mesial wall of the hemisphere, dorsad to Ammon's horn and the area retrosplenialis granularis. Anteriorly it reaches almost the frontal pole of the hemisphere and posteriorly as far as the regio entorhinalis. Practically all of it is situated on the free surface of the hemisphere and no dividing line between it and the regio retrosplenialis agranularis can be seen.

In *Didelphys azarae* the infraradial region occupies the same location as in *Ornithorhynchus*. Ventrally it extends to the subiculum and frontally as far as the frontal pole. There is no division between this region and the regio

retrosplenialis agranularis. It is also a most primitive area and together with the retrosplenial agranular area it forms an area which is remarkably uniform architectonically.

In *Microchiropterae* the regio retrosplenialis agranularis is well developed so that in the bat one finds that the cortex holoprotoptychos quinquestratificatus consists of three regions: regio infraradiata, regio retrosplenialis agranularis and regio retrosplenialis granularis. In this animal the regio infraradiata is divided into a subregio infraradiata ventralis and a larger dorsal area, the subregio infraradiata communis. The characteristics of the subregio infraradiata ventralis are a wide lamina zonalis, a relatively less prominent lamina ganglionaris and the loosely united lamina multiformis and lamina infima. The subregio infraradiata communis shows the following characteristics: The cells of the second to fourth layer are closely packed and distinct under the zonal layer; the lamina ganglionaris (V) is wide and subdivided into two, and occasionally into three layers; the lamina multiformis (VI) is compact.

In *Insectivora* (*Erinaceus europaeus*) the regio infraradiata occupies almost the entire mesial wall of the hemisphere above the taenia tecta from the frontal pole to the posterior part of the splenium corporis callosi. It is subdivided into the subregio infraradiata ventralis, subregio radiata intermedia and the subregio radiata dorsalis. In the hedgehog each of these subregions consists of two subareas, an anterior and posterior one. Here, then, this area has reached a much higher differentiation than in the bat. A well formed and highly differentiated regio infraradiata is also found in rodents.

In *Prosimiae* the wall of the hemisphere is entirely different than in the lower mammals. The sulcus callosomarginalis is distinct and may be regarded as the dorsal boundary line of the gyrus limbicus, although genetically as well as architectonically it consists of two different cortical regions, a dorsal area which is a cortex holoprotoptychos septemstratificatus (isocortex euradiatus) and a ventral one, which is a cortex holoprotoptychos quinquestratificatus. In *Lemur catta* the regio infraradiata in front of the splenium corporis callosi merges into the regio retrosplenialis granularis and agranularis. In higher mammals the limbic region is always overshadowed and partly displaced by the cortex holoprotoptychos septemstratificatus. The differentiation of the regio infraradiata in *Prosimiae* resembles that in *Microchiropterae*, as it is subdivided only into two subregions.

In the chimpanzee the regio infraradiata is in some respects similar to that in half-apes; it covers almost the anterior three-fourths of the dorsal portion of the corpus callosum, and just as in *Prosimiae* it occupies only the ventral portion of the gyrus limbicus, almost its entire lower two-thirds. The dorsal portion of the gyrus limbicus, on the other hand, is of the same structure as the cortex holoprotoptychos septemstratificatus.

In apes the regio infraradiata is much better developed and more differentiated than in lower mammals. The characteristic spindle cells of this region is first noted in apes.

In man the infraradiary region resembles closely that in apes. Here and there the so-called gyrus limbicus can not be regarded ontogenetically as a uniform cortical region. Only the ventral portion of the gyrus limbicus anterior can be regarded as a real limbic cortex, whereas the dorsal part and that lying freely on the surface represents a cortex holoprotoptychos. The continuation of the cortex holoprotoptychos quinquestratificatus is situated in the posterior portion of the gyrus limbicus only in the sulcus of the corpus callosum, i. e., the retrosplenial region. In man then, most of the gyrus limbicus must be included in the cortex holoprotoptychos septemstratificatus, and the regio infraradiata is ever so much more prominent than in apes; in the former it is subdivided into a subregio infraradiata ventralis, subregio infraradiata intermedia and a subregio infraradiata dorsalis. The first of these subregions is characterized by the smallness of its cortex, the remarkable width of the lamina zonalis (I), by a division of the fifth layer into two layers, one of which (V a) is poor in cells and the other

(V b) much richer in cells, as well as by a slight increase in the number of spindle cells, and poorly developed layers (VI) and (VII). The subregio infraradiata intermedia is recognized by its wider cortex, narrower zonal layer (I), a (V a) layer richer in cells and a (V b) layer poorer in cells, a more compact (VI) layer and numerous spindle cells especially in (V b). The chief characteristics of the subregio infraradiata dorsalis are: A widening of its outer principal layer, a specially distinct (V a), and an increasing disappearance of the spindle cells in the caudal direction.

Many authors associate the limbic cortex with the sense of smell. Its exquisite development in primates and especially in man is suggestive that it probably subserves other functions. The theory that it is a cortical representation of the sympathetic nervous system is on anatonic grounds absolutely untenable.

Regio Retrosplenialis Agranularis.—This region is architectonically closely related to the regio infraradiata. Here and there the original granular zone (lamina granularis primaria) remains nonstratified. The elements of the latter in both of these regions are differentiated into medium-sized pyramidal cells. The compactness of the elements beneath the zonal layer, however, is much more definite in the agranular retrosplenial region than in the infraradiar region. The second to the fifth layers, originating from the primary granular zone, are in the regio retrosplenialis agranularis much narrower than in the regio infraradiata.

A close genetic relationship also exists between the infraradiar and retrosplenial agranular cortexes. In *Ornithorhynchus* as well as in *Didelphys* there is found on the mesial wall of the ventricle an agranular cortex holoprotoptychos quinquestratificatus of uniform structure; in the *Didelphys* this cortex lies caudad, and in *Ornithorhynchus*, ventrad to the regio retrosplenialis granularis. In neither of these animals can the borders of the regio retrosplenialis agranularis be made out, so that the regio infraradiata and the regio retrosplenialis granularis still represent one field of uniform structure.

A somewhat more advanced differentiation is found in *Chiroptera.* Here one can readily distinguish the regio infraradiata from the regio retrosplenialis agranularis. Frontally, the latter borders on the regio infraradiata ventralis. In the bat it appears in the form of a long band. A similar relationship between these two regions is also found in *Insectivora.* In the hedgehog the regio retrosplenialis granularis assumes an oval shape. In *Rodentia* the regio retrosplenialis agranularis occupies the lateral surface of the hemisphere although its structure is just as typical as in the other small mammals. In *Prosimiae* the differentiation of this cortex has undergone well advanced differentiation into three subregions. In primates, and especially in man, the regio retrosplenialis agranularis represents a primary agranular field; only in a few areas does one find the slightest indication of a granular layer.

In the chimpanzee only a small part of the retrosplenial agranular region lies dorsad to the splenium corporis callosi on the mesial surface of the brain; most of it is found deeply within the sulcus corporis callosi between the regio retrosplenialis granularis and the cortex holoprotoptychos septemstratificatus.

In man this region is unusually well marked, and, as in other mammals, it has a number of characteristics common to it and to the regio infraradiata. Both of them are primary agranular cortexes, and in both the outer principal layer is narrower than the inner layer. The entire regio retrosplenialis agranularis in man is to be found in the region of the upper lip of the sulcus corporis callosi between the regio retrosplenialis granularis and the isocortex euradiatus. In the myelo-architectonic picture the entire region is supraradiar.

Regio Retrosplenialis Granularis.—Ontogenetically, this cortex is also a cortex holoprotoptychos quinquestratificatus. The difference in the cell picture between the regio retrosplenialis granularis and the regio infraradiata is that the lamina granularis primaria of the former is wholly, or to a great extent, granular whereas in the latter, it contains almost exclusively larger and smaller pyramidal shaped cells. Exclusively granular elements in the second to the fourth layers

of the regio retrosplenialis granularis were found by Rose in the bat, dog, *Lemur catta* and in *Didelphys*, whereas in the rabbit, hedgehog, *Ornithorhynchus* and especially, in apes and in man, the layers contain in addition to granular cells, also medium-sized and even large pyramidal cells. The latter are closely packed underneath the zonal layer. The first, fifth, sixth and seventh layers are the homologues of the same layers of the cortex holoprotoptychos septemstratificatus. The narrowness of the outer principal layer as compared to that of the inner is much more marked in the retrosplenial granular cortex than in the infraradiar.

As far as the differentiation of the retrosplenial region into subareas is concerned it may be said that most primitive conditions are found in *Monotremata* and *Marsupialia*. In *Ornithorhynchus* a small surface of this region is situated ventrad to the regio infraradiata and dorsad to the regio praesubicularis. It presents a uniform structure throughout its entire extent and its differentiation is primitive. Conditions are practically the same in *Didelphys* except that the size of this region is absolutely as well as relatively greater than in *Ornithorhynchus* and its differentiation is somewhat more advanced.

In *Vespertilio murinus* the regio retrosplenialis granularis also presents a uniform structure throughout its entire extent, and is in the form of a narrow band in the mesial part of the hemisphere between the regio retrosplenialis agranularis and the regio infraradiata. Although its differentiation in this species is not high, nevertheless it is much higher than in *Didelphys* and especially in *Ornithorhynchus*. The narrowness of the second to the fourth granular layer is striking, a common characteristic of the retrosplenial granular region as well as of the entire cortex holoprotoptychos quinquestratificatus.

In the hedgehog the entire retrosplenial granular region is situated ventrad to the retrosplenial granular region. The surface of the former is relatively small and shows comparatively little differentiation. In the mouse the regio retrosplenialis granularis is an extensive and well developed structure, which is divided into two areas, the area retrosplenialis granularis ventralis, and the area retrosplenialis granularis dorsalis. In half-apes the retrosplenial granular region is well developed, and is also divided into two areas. A well developed regio retrosplenialis granularis is also found in *Lemur catta*, and has the same characteristics as in the dog.

In primates the entire regio retrosplenialis granularis is found deeply within the sulcus corporis callosi; both in its development and subdivisions it resembles those between the apes and man. In the chimpanzee this region is divided into three parts: The area retrosplenialis granularis medialis; a regressive area containing in the second, third and fourth layers small pyramidal shaped cells in addition to the granular cells. The area retrosplenialis granularis intermedia which represents the best developed type of a granular retrosplenial cortex; its second to fourth layer consists almost exclusively of granular cells. In the area retrosplenialis granularis lateralis the second to the fourth layer consists of small and medium-sized pyramidal cells lying underneath the zonal layer, and of a granular layer.

In man the regio retrosplenialis granularis is also divided into three areas. As in the chimpanzee the area retrosplenialis granularis medialis is also a regressive one; it contains in the second to the fourth layer a considerable number of small pyramidal cells in addition to many granular cells. The area retrosplenialis granularis intermedia contains in the second to the fourth layer chiefly granules, and only a few pyramidal cells. The area retrosplenialis granularis lateralis resembles that found in rabbits; in the second to the fourth layer, larger elements are found beneath the zonal layer and granular cells still deeper.

The extensive regression of the regio retrosplenialis granularis in man has led many authors to regard this cortex as an olfactory center. As a matter of fact this region is much better developed in many mammals than in man. Comparing the relations in individual mammalian orders, however, one finds that the regio retrosplenialis granularis shows the greatest development in

rodents, whereas in insectivora, whose olfactory power is far superior to that of rodents, this region is much more poorly developed and less differentiated. In the hedgehog the differentiation is not much better than in the primates in spite of the fact that the olfactory power of the latter is far superior to that of the former. In *Didelphys azarae,* another species with a well developed olfactory function the regio retrosplenialis granularis also shows much poorer development than in rodents. In the dog this region is well developed, although in half-apes (*Lemur catta*) animals with an inferior olfactory function this area is just as well developed. As far as differentiation of this area is concerned the dog is definitely behind the rabbit.

KESCHNER, New York.

THE FIBER SYSTEMS OF THE SUBSTANTIA NIGRA AND THE BASAL GANGLIA IN PARKINSONISM. AKIRA KAWATA, Arb. a. d. neurol. Inst. a. d. Wien. Univ. **29**:265 (Sept.) 1927.

Since the cells of the substantia nigra are practically destroyed in a large proportion of cases of parkinsonism following epidemic encephalitis, it is conceivable that the fibers arising from these cells may show degenerative changes. Kawata made serial sections in six cases in which there was destruction of the substantia nigra, using his own modification of the Weigert-Pal staining technic.

One is oriented by a review of the voluminous literature on this subject. Bauer recognized fibers arising in the lateral part of the substantia nigra and running toward the central gray substance, and named them the fibrae efferentes substantiae nigrae. Orally he found in the same region a dense fibrous structure known as the fibrae subthalamicae substantiae. Sano recognizes in the substantia nigra approximately the same fiber systems as Marburg describes in his atlas. He designates the ventrolateral, horizontally cut fibers as the lateral pontile bundle which appears to adjoin an accessary system farther laterally. He designates the systems lying dorsal and somewhat medial from this as D.l. and D.m., the lateral one corresponding to Marburg's fasciculus subthalamicopeduncularis. In horizontal sections Körniey has actually shown fibers passing from the corpus subthalamicum to the substantia nigra; so the expression "fasciculus subthalamicopeduncularis" is justifiable. Medial to this is a delicate network of fibers (Sano's D.m.), while ventrally (lateral to the fasciculi pontini laterales) lies an area known as the stratum intermedium.

Since Jakob and Wallenberg have shown that the so-called lateral pontile bundle is a pallidofugal pathway, this structure has been receiving considerable attention. Riese does not believe in the cortical origin of the stratum intermedium, but thinks that it has a direct connection with the striatum through the tractus striomesencephalicus ad substantiam nigra. He also believes that the fasciculi pontis laterales arise from the caudal part of the pallidum, and that the fasciculi pontis mediales are cortical systems. After numerous experiments and in the light of researches by other workers, Poppi concluded that the structure in the substantia nigra heretofore known as the lateral pontile bundle really had nothing to do with this bundle since this lies much farther medially. He called the actual lateral pontile bundle the frontopontotegmental system which merely traverses the tegmentum and really goes down into the pons. A second analogous system coming from the temporal cortex is known as the temporopontotegmental system. What was formerly considered the lateral pontile bundle is really a pallidopeduncular system. In this system lies the subthalamicopeduncular bundle the existence of which has been substantiated by the researches of Körniey. The delicate fibers lying ventral to this system are known as the fasciculus pedunculomesencephalicus.

Kawata then reports the observations in his own preparations:

CASE 1.—The pallidum is intact in the caudal sections, but orally the fibers have been damaged. The same applies to the striatum. Further, there is

some rarefaction of fields H 1 and H 2, while the corpus subthalamicum and the commisura hypothalamicae are absolutely intact. What has suffered is the substantia nigra which appears to be shrunken in all directions and in whose fiber systems one recognizes only a fairly well-stained medial and lateral division. Caudally, the interposed stratum intermedium is absent and orally is only barely discernible. Further, the fine fibers having connection with the corpus subthalamicum can be recognized. The other finer fiber systems are no longer present.

CASE 2.—In Weigert preparations of the nucleus lenticularis there is no definite degeneration of the fibers from the putamen to the globus pallidus, and the same is true for the nucleus caudatus. All systems connected with the globus pallidus remain intact, and the only changes are found in the substantia nigra. In this case the latter is almost completely destroyed except for the pallidopeduncular system which is, for the most part, spared. The stratum intermedium has been severely affected, and that fine network of fibers ordinarily found in the substantia nigra is absent. The fasciculus temporopontinus is only slightly developed.

CASE 3.—The conditions in this case were analogous to those in the preceding one.

CASE 4.—In this again there is destruction in the substantia nigra. As far as the fibers are concerned this involves chiefly the intermediate portion of the stratum intermedium, especially the caudal and middle thirds. Further, it shows that principally the striopallidal fibers are involved, while the other systems remain practically intact.

CASE 5.—Here, while conditions in the substantia nigra are identical with those in the preceding cases, the fibers of the basal ganglia remain unaffected with the exception of the anterior third in which the striopallidal fibers are severely damaged on one side.

CASE 6.—Here there is partial destruction of the striatum and pallidum, while the substantia nigra shows conditions analogous to the preceding cases. In places the outer segment of the globus pallidus is damaged.

Kawata concludes from his studies that the fasciculus pallidopeduncularis is, for the most part, spared, and only the fibers which lie ventral to it and orally course medialward to establish connection with the stratum intermedium are most severely damaged. In this pallidopeduncular system there are fibers which run into the tegmentum of the mesencephalon. Connected with this system are also fibers which run dorsomedially in the substantia nigra and form a fine network medially to the fasciculus subthalamicopeduncularis. These fibers do not actually belong to the substantia nigra, for in this even they would have been severely damaged. On the other hand, there was serious damage to the stratum intermedium especially in its intermediate region. Therefore one must assume that the intermediate part of the stratum intermedium has an important connection with the substantia nigra. The connection between these fibers and the tegmentum is difficult to establish, although it has been seen how some fibers have occasionally degenerated.

It was striking that in all six cases of parkinsonism of several years' duration most of the fibers connected with the pallidum remained intact. A single system showed changes of varying degree in all cases and that was the fibers going from the striatum to the pallidum. Therefore, in the fiber degenerations in parkinsonism there is actually a two-fold destruction: (1) of the striopallidal fibers, and (2) of the stratum intermedium which apparently contains principally fibers originating in the substantia nigra and coursing caudalward. Some plunge ventrally into the peduncle and run caudally with it, while others are connected with the tegmentum by the fibrae rectae mesencephali.

KAMMAN, Saint Paul.

THE LIVER IN THE ETIOLOGY OF NERVOUS DISEASES. MICHAEL LAPINSKY, Deutsche Ztschr. f. Nervenh. **97**:95 (April) 1927.

Like all other large glands the liver is capable of influencing the nervous system in a dual manner: (1) in accord with the neurotropic law, the wave stimuli streaming along the particular centripetal tract which unites a particular visceral organ with the nerve centers will either stimulate or inhibit the nerve centers over a circumscribed area; (2) again, as a result of biochemistry (chemotaxis, toxins, hormones, "correlation" of the various biochemical parts and other biochemic mechanisms), which exerts an influence not only on the nervous system but also on many other parts of the body, stimulating one organ to greater activity and inhibiting another.

As regards the neurotropic influence of the liver on nerve centers, it is known that in early fetal life this organ is in relation to the medulla, and in a later embryonic period has centripetal association with the dorsal and first two lumbar segments. This conception finds its confirmation in the relation of the liver to the vagus, sympathetic, phrenic and motor nuclei of the fifth to the eighth cervical segments as a glycogenic center in the cervical swelling and to the dorsal and lumbar area as the vasomotor center for the liver.

Concerning the biochemical influence of the liver on the nervous system it is accepted that when urobilinogen is found in increased quantity in the urine, there is a diminished glycogen function of the liver. But the biochemical influence of the liver on the nerve centers depends in the first place on the participation of this organ in digestion by means of its external secretion and again on the ability of the liver to neutralize or to excrete certain products and make them harmless to the nerve centers. Again, through the internal secretion, the liver is able to bring about a correlation between itself and other organs of the body, acting either as agonist or antagonist.

On careful examination of a number of patients labeled with the diagnosis of neurasthenia, no apparent change can be found in the nervous system. The clinical picture shows merely a functional disturbance. The complaints of the patients are many and changeable. They complain of general tiredness, difficult thinking, diminished memory power, depressions, unpleasant dreams, insomnia, pressure feeling in the epigastrium, pain between the shoulder blades or along the spine or in the back of the neck, headache and loss of appetite. Gastric examination usually gives negative results; the same is true with the blood examination. The stools will often show a diminished absorption of fat. The urine on the other hand will show an increase in urobilinogen, indoxyl and scatoxyl. On the basis of such symptoms one can speak with certainty of insufficiency of the liver in both its internal and external secretions, and in its filtration power and of a disturbance in the blood circulation. Treatment tending to bring about a restoration of the function of the liver will bring the nervous system to a normal state and the neurasthenic symptoms will disappear.

In evaluating the importance of the filtering power of the liver in the etiology of disease of the nervous system, one must also consider the toxicity of the intestinal chyme. When an extract of intestinal chyme is injected in a peripheral vein of a rabbit, the animal dies in a few minutes. On the other hand, a much larger quantity of the same extract can be injected in the portal vein without bad effect on the animal. When an animal is injected with blood from the portal vein, the same toxic symptoms are noted: somnolence, salivation, mydriasis, ataxia and tremor of the musculature.

The seriousness of autointoxication in insufficiency of the liver is shown by the Massen-Pawlow experiment in which an anastomosis is made between the portal vein and the vena cava inferior, thus cutting off the portal circulation. Such animals show a change of character, become apathetic, irritable and soon die with symptoms of autointoxication. A similar clinical picture is obtained either by ligating the hepatic artery, or by the use of sulphur or

acetic acid. The experiments teach that normal activity of the brain is possible only when the liver is capable of properly purifying the portal blood. According to Widal, this organ protects the animal from an overflow of protein products into the blood, which are found circulating in uremia, arteriosclerosis and other chronic ailments.

Many other organs depend on the proper functioning of the liver; among them may be mentioned the stomach, the spleen and the kidneys. The circumstances, however, that in insufficiency of the liver the toxicity of the blood remains unchanged, and the requirement of the nerve centers for particular chemical nutritive material, and the fact that each nerve center possesses a special chemotoxic coefficient in attracting only particular substances makes the condition of the liver in the etiology of nervous disturbance especially important.

Many investigators have found a disturbance of the central nervous system in diseases of the liver. Bonhoeffer holds the liver responsible in autointoxication psychoses. Economo and Schilder explain their reported cases of diseases of the basal ganglia by a primary disturbance of the liver. Kirschbaum, in a reported case of atrophy of the liver found changes in the cortex, corpus striatum and cerebral blood vessels. In Wilson's disease, pseudomultiple sclerosis and Huntington's chorea, a disease of the liver is found. In the experimental field, Fuchs, Eugene Pollak, Lewy, Pinkussen, Kirschbaum and Widal have shown the importance of normal activity of the liver to normal function of the brain.

BERNIS, Rochester, N. Y.

FINGER NAILS, TERMINAL PHALANGES, RACE AND CONSTITUTION. ERWIN STRANSKY, Jahrb. f. Psychiat. u. Neurol. **45**:292, 1927.

Stransky comments on the fact that so little attention has been given by neuropsychiatrists to this subject—"at least," he says, "in the German literature." He refers to Heller's observations on the size of the lunula in various races and to the investigations by Martin, Brezina, Lebzelter and others on the formation of the hand and its relation to race and constitution. In none of these communications nor in that of Baur-Fischer-Lenz or in Kretschmer's book on "Body Structure and Character" is there any mention of the nails and terminal phalanges. Nevertheless, one finds in general and special pathology numerous references to the appearance of the nails and terminal phalanges in various pathologic conditions. Some of these references are: The "hippocratic" nails curved in the palmar direction and almost always associated with "drum-stick fingers" in pulmonary and cardiac disease, which must not be confused with the peculiarly shaped finger ends encountered in acromegaly. Acquired changes in the nails and terminal phalanges are also observed in the many forms of trophic disturbances. Peculiar changes in the nails and fingers are also encountered in cases of maldevelopment, such as unilateral or bilateral abnormal widening of the terminal phalanx of the thumb with proximodistal shortening of the nail; some of these are considered as incomplete forms of polydactylism and syndactylism which may also be familial in nature. Stransky is unable to state whether the wide and short nails of the thumb occasionally observed by him in young feebleminded epileptic patients are of similar significance.

Frequent deviations from the normal have been observed by the author in schizothymic persons: instead of the usual slightly concave shape of the terminal phalanx of the thumb the entire thumb is straight, especially during adduction and abduction; this deformity is occasionally associated with a tendency to slight subluxation of the metacarpophalangeal joint of the thumb. In other neurotic persons, especially in those whose mental make-up approximates the feminine type, the nails of all fingers are more or less straight and thin and appear as if they were elevated above the nail-bed, whereas the volar surface of the terminal phalanx is strikingly flat and poor in adipose tissue. Other abnormal persons show a tendency to a clawlike appearance of the nails, especially of the index finger. In neuropathic persons with arthritic tendencies in the finger joints the margins of the nail plates are not more square shaped than normally,

and the nails themselves, even in younger persons, are more longitudinally striped than normally (in old persons this longitudinal striping is common) whereas the distal margins of the nails are much more raised than ordinarily. In certain psychopathic persons the asymmetry of the fingers and nail-beds is striking. In adipose persons (these do not include the Froehlich type) he observed two types of "fleshy" fingers: one with well developed phalanges and well proportioned rectangular oval nails on the four outer fingers and a normal wider quadrilateral nail on the well formed thumb, all nails being rather flat than arched; the second type was characterized by small thin phalanges and small, thin, short, brittle, distally elevated nails on the four outer fingers with the thumb equally thin and its nail resembling that of the other fingers. Both of these types were found in both sexes; the second, apparently the "asthenic" type, was more frequent in females and in more markedly neuropathic persons, whereas the first type was found in less neuropathic persons. Although these observations were most striking in adiposed persons, thin people occasionally showed similar conditions especially those of the second type.

Stransky found slender and at the same time well built terminal phalanges with proportionately strong nails unusually common in persons of "Nordic" complexion and type. In persons of "Slavonic" type the fingers were also unusually well built, but the nail formation had certain peculiarities differing from the "Nordic": The nail plates (including those of the thumbs) appeared somewhat narrower and "trapeze shaped" with varying intensity of the radio-ulnar arching, the lateral nail wall protruding well beyond the nail-bed, "the entire finger portrait having a more neurotic feminine coloring than in the Nordic type." In dark-complexioned persons (gypsies) the phalanges were slender, moderately strong, with thumbs that were not too broad and rectangular well curved nails; the nail walls were strikingly low, almost absent, with the distal end raised above the nail-bed for an unusually long distance; a similar condition was observed occasionally in connection with a shorter and more round nail configuration. In persons belonging to the yellow races the ends of the fingers were strikingly less padded, the terminal phalanges being flatter in the dorsopalmar direction and covered with relatively broad (the phalanges were mostly narrower than in the other races) and more rectangular nails. There was no peculiar type of finger or nail to be seen in native Western Jews, whereas in Eastern Jews there was some approach to a type: The phalanges of the fingers and thumbs were often narrow and thin; the terminal phalanx of the thumb was strikingly short and straight; the nails of all fingers were short, thin, brittle and often covered with their distal ends or overhanging the tips of the fingers. Stransky does not know whether one is dealing here with an anthropologic racial or merely with a constitutional characteristic but curiously enough fingers and nails of this type are frequent in severely neuropsychopathic persons and in those with compulsion neuroses; the fact that compulsion neuroses are very common among Eastern Jews may be of some significance.

The paper is concluded with a caution that in a study of this kind, before conclusions are drawn as to the grouping of these various types of fingers and nails such factors as nail biting, fashions in manicuring and nail changes in the course of intercurrent diseases, etc. must be taken into consideration. In the author's opinion the subject of dactylology and onychology has hitherto been neglected; to him it would appear to be a fruitful field for investigations of this type, especially in the study of constitution and race.

KESCHNER, New York.

PSYCHIC COMPULSION PHENOMENA AND THEIR GENESIS IN CASES WITH ENCEPHALITIC OCULAR SPASMS, WITH A NOTE ON THE GENESIS OF ENCEPHALITIC OCULAR SPASMS. F. STERN, Arch. f. Neurol. u. Psychiat. **81**:522 (Sept.) 1927.

The author discusses the occurrence of compulsion phenomena in cases of epidemic encephalitis with ocular spasms, and attempts to reduce the two to a common pathologic basis. He defines compulsion ideas as those that enter consciousness under a subjective feeling of compulsion, and although the patient

recognizes them as false and pathologic he cannot get rid of them; they lead to inhibitions and interferences in behavior. Phenomena of this type have been regarded as essentially functional, but within recent years they have been described in organic conditions of the brain, especially in postencephalitic cases. In the author's experience these have occurred particularly frequently in cases in which postencephalitic ocular spasms have occurred; this led him to investigate the possibility of a common pathologic basis. He describes the ocular spasms as follows: they are spasmodic conjugate movements of the eyeballs either directly upward or upward and to one side; they vary in intensity, occur at irregular intervals and last from several minutes to several hours. The eyelids show a synergic contracture upward. There is frequently a rotation of the head backward and laterally. The upward deviation is most frequent, although at times the spasms may cause the eyes to remain fixed in some other position (e. g. staring directly forward). They occur frequently after intensive work or exhaustion, and at times disappear only after prolonged rest or sleep.

The author describes six cases in which these spasms were accompanied by compulsion phenomena. An analysis of the compulsion phenomena shows that psychologically they can be reduced to the following elementary components: (1) a feeling of anxiety (Angst) which seems to be present not only in these cases but also in other cases of ocular spasms, and which apparently precedes the actual compulsion phenomenon as well as the ocular spasms, and (2) a sudden "sticking of thought" resulting in a persistence of a certain thought content and inability to concentrate on anything else. The possibility that these two components (which the author considers as elementary psychic processes) might be caused by the ocular spasm itself is contradicted by the fact that they occur before the spasm. The question concerning the possibility of these mental processes, as well as the ocular spasms in themselves, being of autosuggestive or purely psychogenic nature is discussed, and the author comes to the conclusion that like many other postencephalitic symptoms these may be exaggerated by functional superstructures. The nucleus of the reaction, however, must be considered as primarily due to the pathologic changes in the brain. The author is aware of the fact that the nature of the compulsion phenomena and compulsive thoughts and their contents cannot be said to originate in any particular center of the brain, but it is only these elementary components of anxiety and thought perseveration that he would be inclined to associate with the pathologic process which is responsible for the ocular spasms. A third mental component, which is not so frequent as the other two, but which is found in some cases, is that of a restriction of the field of consciousness.

As to localization of these phenomena, he feels that it cannot be looked for in a condition of the ocular nuclei themselves but must be dependent on pathologic changes located further centrally. The accompanying reflexes of the neck and of the labyrinth and the turning of the body suggests a vestibular involvement. Investigation of these reflexes, both by the Bárány tests and Magnus-DeKlejn reflexes, shows that the most probable underlying mechanism of the ocular spasm is a disturbance of the vestibular apparatus with special involvement of the posterior longitudinal bundle. The psychic components, the anxiety and thought perseveration he thinks must be due to a pathologic lesion localized about these regions too, most probably in the brain stem. This is rendered more probable by the recent investigations which show a definite relationship between affective processes and this part of the central nervous system.

MALAMUD, Foxborough, Mass.

THE VASCULAR SUPPLY OF THE CEREBRAL CORTEX. R. LORENTE DE NÓ, J. f. Psychol. u. Neurol. **35**:19, 1927.

This investigation was carried out with preparations derived from apes (*Nemestrinus*) and rabbits. The parts studied were Ammon's formation and the area entorrhinalis, the occipital lobe, especially area striata and peristriata, and

some parts of the temporal lobe. The preparations were stained by the Golgi-Cox method. Special attention was paid to the capillary network. The first and most striking condition was the enormous number of capillaries in the cerebral cortex. This is definitely the most compact network in the entire body. It is absolutely interminable. All large vessels, both arteries and veins, give off innumerable branches and anastomoses so that there are no "terminal areas." One can reach from the olfactory bulb to the occipital lobe without leaving the network. The fairly uniform caliber of the capillaries and the formation of capillary loops are striking features both of which enable the blood to be waylaid in a thousand different channels in order to reach from one point to another. If the capillary system was a rigid system there would be many areas in which the blood could never be renewed. The quantity of blood flowing through a vessel would in that case, determined only by the resistance against the current, supply the vessels, so that the blood would not enter the capillary loops which represent a complicated channel; it would circulate much more easily through the straight channels. To enable the blood to pass through the loops it is essential that the straight channels of capillaries be constricted or even closed.

Although the capillary network is identical in structure throughout the brain, there exist nevertheless some regional differences, a knowledge of which may be said to constitute the angiotectonics of the brain. There is, however, no comparison between the angiotectonic and the cytotectonic or the myelotectonic structure of the brain. The cells and fibers constitute the fundamental elements of nerve tissue, whereas the vessels are subordinate elements whose chief function is to supply nutrition to the former. The arrangement of the vessels then depends on the arrangement of the cells and fibers. A knowledge of this relationship between the vessels and the cells and fibers will enable one, on cyto-architectonic grounds, to construct a priori a scheme for the arrangement and number of the vessels. This relationship seems to be simple: where the metabolic processes are most active, there the number of capillaries also seems to be the largest. That the need for nutrition is much less in nerve fibers than in cell bodies and their protoplasmic prolongations is evinced by the presence of fewer capillaries in fiber systems and of larger numbers of capillaries in cellular areas. The Nissl or Weigert strains do not give definite information as to the number and mode of division of the protoplasmic prolongations; the relationship between the number of these and the vascular supply can be appreciated only in Golgi or Cox preparations.

A few examples will clarify the subject: The first layer of the cortex contains considerably fewer cells than the seventh layer; from this may be concluded that the number of capillaries in layer I is considerably smaller. The opposite, however, is true: the first layer is richer in capillaries than the seventh layer. The reason for this lies in the fact, established by Cajal, that the prolongations of all the pyramidal cells and of a large number of cells from the sixth and seventh layers enter the first layer so that it contains an unusually complicated plexus of protoplasmic prolongations which demand a rich blood supply. In the sixth and seventh layers there is an enormous number of nerve cells, but their prolongations are to be found not in these layers but in those above. The consequence is that, in spite of the large number of cells, the amount of protoplasm in this layer is less than in the first layer. Similar conditions exist also in the area striata.

It must also be borne in mind that all cells in the cortex do not function at the same time, a certain number of them only function at one time; these demand a richer supply of nutritive substances and consequently of blood. From this it may be concluded that the capillaries in the cortex are constantly changing in caliber just as is the case in other organs. The author ventures the hypothesis that the glia cells, whose prolongations cling to the walls of the capillaries, may be a factor in regulating the caliber of the capillaries.

KESCHNER, New York.

THE NATURE OF PUPILLARY RESTLESSNESS. OTTO LOWENSTEIN, Monatschr. f. Psychiat. u. Neurol. **66**:126 (Oct.) 1927.

Under the term pupillary restlessness the author groups all those finer movements to which the margin of the iris is continuously subject. The movements do not involve the margin of the iris as a whole, but consist of local contractions and dilatations. There is a certain resemblance to peristaltic activity, one point contracting while a neighboring point dilates. Almost no point in the circumference is quiet. The speed of the movements varies in different persons, and in the same person at different times. The extent of the movement also varies, rarely exceeding 0.5 mm.

Pupillary restlessness occurs as a physiologic phenomenon in normal persons; it is independent of the intensity of illumination (as soon as adaptation has occurred), the size of the pupils and the degree of convergence. The movements are rapid, from 30 to 120 per minute. They are more or less rhythmic. They are essentially dependent on a continuous and variable stream of sensory impulses flowing into the iris through the nervous system from all sources. In addition to pupillary restlessness, there are other movements of the pupil which are more striking and of greater amplitude. These are definitely of psychic origin, occurring under the influence of strain, excitement, emotion, etc. But between the movements of psychic origin and the true pupillary restlessness all gradations occur, so that one cannot tell the exact moment at which the one type passes over into the other. Hippus represents still another type of pupillary movement. Views as to its causation differ. Behr considers it a marked, rhythmic, concentric movement of the whole pupillary border. Willbrandt and Sanger consider it an exaggerated form of pupillary restlessness and believe that all gradations between the two occur. They state that the movements of hippus are independent of light, of convergence, and of sensory and psychic stimuli. Damsch states that the movements of hippus are entirely irregular and the individual contractions of variable extent and duration.

The author summarizes his own views as follows:

Pupillary restlessness is essentially independent of psychic processes. It depends on periodic tonus variations. These are identical with the tonus changes, constantly occurring in all parts of the body at all times. They are easier to recognize in the pupil than elsewhere, because the iris ends in a free border which serves as a delicate indicator.

Pupillary restlessness is different from the "expression movements" which are the expression of psychic processes, and which also cause a constant change in the degree of muscle tone. By adequate graphic methods these pupillary changes, dependent on psychic stimuli, can be separated from the movements of pupillary restlessness.

Hippus differs from pupillary restlessness in the fact that the movements are wider, more rapid, and concentric. There may be a single movement or a rapid series. Hippus, like pupillary restlessness, is independent of sensory or psychic stimuli. As for pupillary restlessness, however, an existing hippus is modified, both in form and rhythm, by psychic or sensory stimuli.

Pupillary restlessness is present in all persons; hippus is not. The tendency to hippus production is an individual thing, which is shown by certain normal persons and not by others. The essential basis for its occurrence is unknown. Hippus is probably analogous to the nonpsychogenic tic.

SELLING, Portland, Ore.

THE DIENCEPHALON OF THE ALBINO RAT: STUDIES ON THE BRAIN OF THE RAT. E. S. GURDJIAN, J. Comp. Neurol. **43**:1 (April) 1927.

This extensive paper is part of a series of contemplated contributions on the brain of the albino rat and forms part of a comprehensive investigation of the diencephalon in a series of vertebrate brains which Dr. G. C. Huber and his collaborators have undertaken. Included in this paper is a useful account of various methods employed in preparing the material for this study. The paper

has been confined chiefly to a record of observed facts. A detailed consideration is given of the hypothalamus (including the mammillary bodies), the metathalamus, optic and postoptic systems, the subthalamus (excepting the substantia nigra) and the thalamus proper. The epithalamus (fully described in a previous paper [*J. Comp. Neurol.* **38**:1, 1925]) is considered for the sake of completeness in this description. Attention is often called to a phylogenetic significance of the facts as they are brought out. Thirty fully labeled figures taken from various levels of the brain show the numerous nuclei and fiber tracts discussed in detail in the text.

Only a few of the salient features in this paper can be brought out in this abstract. Among them are the following: 1. Numerous connections are described in the complex nuclear configuration of the hypothalamus in which twelve nuclear masses can be differentiated. 2. A close continuity between the hypothalamus and the subthalamus (a highly organized center in the rat) is emphasized. It is suggested that these areas have some related groups of functions. 3. An extensive interrelation exists between the preoptic, hypothalamic and amygdaloid complex by three different paths, the significance of which the author of the paper is not prepared to offer at present. 4. The medial forebrain bundle is essentially a medium of connection between the anterior olfactory centers and the hyothalamus. It is suggested that it may also send some fibers to the medial parts of the subthalamus. 5. The supra-optic group of commissures is concerned primarily with the metathalamus, subthalamus, tectum and a portion of the hypothalamus. 6. Attention is drawn to an important fact, hitherto overlooked, that the zona incerta of the highly organized subthalamus of the rat takes on the function of a correlation center through its connections with the internal capsule, tectum, tegmentum and hypothalamus. 7. The optic tract and the metathalamus are considered. Definite corticogeniculate fibers are shown in the rat, representing another step in the phylogenetic development of the brain when compared with lower forms. The view is expressed that such a tract in the rat demonstrates the increasing importance of the cortex and the ability of the latter to subjugate a center like the metathalamus, which, in lower forms, was predominated by the tectum. 8. The thalamus proper in the rat was found comparable to related forms, such as the mouse, rabbit and cat. The anterior group of nuclei were found essentially the same as in mammals, including the monkey. The lateral group of nuclei showed certain peculiarities which are discussed in some detail. Commissural bands connecting symmetrical portions of the thalamus are well defined and appear to play an important rôle in the thalamus of the rat.

STONE, New Haven.

HYPOPHYSEAL TUMORS AND SIMMONDS' HYPOPHYSEAL CACHEXIA. EMIL REDLICH, Jahrb. f. Psychiat. u. Neurol. **45**:276, 1927.

In 1914, Simmonds described a new syndrome which he designated "cachexia of hypophyseal origin" because the most striking symptom was extreme cachexia. He attributed the condition to a total necrosis of the anterior lobe of the hypophysis which he found anatomically in a puerperal case of septic embolism. A considerable number of cases of this syndrome have since been reported, in a majority of which the pathogenesis was similar to that of Simmonds' case. A similar symptom-complex involving the hypophysis has also been described in infectious diseases, especially tuberculosis and more frequently syphilis, as well as in hypophyseal tumors. In the cases of tumor the problem is much more complicated because here the hypophysis may be involved only indirectly through pressure leading to atrophy, and in addition the clinical picture may be complicated by the cerebral manifestations. Borchardt, therefore, recognizes a different form of hypophyseal cachexia which he designates the "hypophyseal-cerebral form."

A classical case of hypophyseal cachexia is characterized by severe cachexia in which the patient becomes reduced to a skeleton and appears senile with a dry, scaly and wrinkled skin. The skin may also show various vasomotor and

trophic disturbances, redness, cyanosis and swelling; in some cases, the skin may resemble that observed in myxedema and scleroderma. Various degrees of baldness and loss of teeth without preceding caries are not uncommon. All subjects of the disease almost invariably complain of symptoms referable to dysfunction of the anterior lobe of the hypophysis: constant myasthenia, with exhaustibility which appears on the slightest exertion and is so profound that the patients are unable to be up and about and become bed or chair ridden early in the course of the condition. Many of them complain of continuous cold or have frequent sensations of chilliness. Bradycardia and arterial hypotension are common. Severe anemia, low metabolism (water and mineral metabolism) and disturbances in the genital functions (amenorrhea, atrophy of the uterus and ovaries and impotence with gonadal atrophy in males) complete the classical clinical picture. To these glandular disturbances, however, must be added nervous and psychic disturbances which appear in one form or another and vary greatly in different cases. Among these may be included apathy, loss of interest, inability to concentrate, emotionalism, disturbances in memory and somnolence. Here and there a case will show hallucinations, delirium and epileptiform seizures. These neuropsychiatric disturbances, however, are much more frequent in the cases of tumor.

According to Redlich, Simmonds' conception of the pathogenesis of the disease finds confirmation in the therapeutic results following the administration of preparations of anterior lobe of pituitary. Diagnostic difficulties are constantly encountered in cases of cachexia that are occasionally encountered in pluriglandular insufficiency and in diseases of the tuber cinereum due to inflammation or tumor.

KESCHNER, New York.

THE INCREASE IN SUICIDAL ATTEMPTS AND ITS CAUSES. W. OPPLER, Arch. f. Psychiat. **82**:95 (Oct.) 1927.

The author reports the results of a comparative study of suicidal attempts before and after the World War. The study is restricted to the population of Breslau. From 1909 to 1913 represents the prewar period; from 1920 to 1924 the five year period after the war. Although the author investigated mainly suicidal attempts, i. e., such as were not actually carried out, he also reviews the number of actual suicidal deaths during the same periods. Most persons who made suicidal attempts were, as a rule, sent to the hospitals for mental diseases for examination, but to make the study as complete as possible the author also considered those patients who were sent to general hospitals and for some reason or other did not reach the hospitals for mental diseases. He finds that the number of actual suicides shows a slight decrease for the postwar as compared with the prewar period, which contradicts the statements made by some observers that the difficult conditions following the war have caused an increase in suicides. The number of suicidal attempts, however, shows a definite and marked increase for the postwar period. This is especially true of such attempts by women which show exactly twice as many cases for the five years following the war as for the years 1909 to 1913. These suicidal attempts are restricted to definite and apparently seriously intended efforts. A revision of the diagnoses made in these cases shows that the increase is due mostly to an increase in attempts made by psychopathic personalities, although some increase is seen too in persons with other types, such as manic-depressive psychoses, schizophrenias, etc. This does not seem to depend on an increase in the admission rate of psychopathic personalities, as this does not show any change. The reasons given by the patients for the attempts show that among the men it was most frequently a difficult economic situation, whereas among women it was mostly some criminal act with pending punishment. Love affairs and marital difficulties do not seem to play any important rôle in either sex. The author sees as a reason for the increase in suicidal attempts not only the more difficult economic situation following the war, but also the poor training and education received by these

persons during the war. The fact that the increase in attempts is accounted for largely by an increase in attempts by psychopathic persons probably explains the fact that there is no increase in actual suicides carried out. It seems that whereas the psychopathic person with a poor early training would be more likely to act on the spur of the moment in deciding to attempt suicide, he would not make as definite and efficient arrangements as persons with the other types of mental diseases, and, therefore, even a seriously intended attempt may go wrong. The author believes that this study would gain in value if similar studies were undertaken in other countries.

MALAMUD, Foxborough, Mass.

PUPILS AS AN AID TO DIAGNOSIS IN COMA. WILLIAM C. MENNINGER, J. Nerv. & Ment. Dis. **65**:553 (June) 1927.

The pupillary status, including equality, size and reaction to light, has been analyzed in 225 cases of complete coma. In fifty-eight cases of alcoholism, inequality occurred in 13.8 per cent — enough to suspect that it was more than accidental. In this state 43.1 per cent showed contraction and nearly one-half responded promptly to light stimulation, while the rest were fixed. In alcoholic coma, the pupils show too great a variation to be diagnostic. In ten cases of diabetic coma there was no uniformity in the observations; in two fatal cases the pupils were fixed. In eight cases of uremic coma there was variation in size, but the light reflex was impaired in varying degrees in other cases, in one of which the pupils were fixed. Of forty-six cases of cerebral hemorrhage, anisocoria was present in three-fourths. The dilated pupil usually occurred on the side corresponding to the hemorrhage, but this depended on the location and extent of the hemorrhage. There was no uniformity in the size of the pupils in such cases; a slight majority in this series were contracted; nearly one-half the series were entirely fixed. In five cases of pontile hemorrhage, all pupils were uniformly contracted and were either sluggish or fixed to light.

In forty-three cases of carbon monoxide poisoning there was a marked variation in size and reaction to light. About one-half the cases showed prompt reaction to light, although one third of the pupils were fixed. In fifty-five cases of fractured skull, anisocoria occurred in over one-third; in 81 per cent of the cases there was either proof or evidence that the dilatation occurred on the side of the trauma of the brain. The inequality was fleeting in many cases, and, when observed, was an indication for surgical intervention. The size varied at different stages and was not uniform. Slightly less than one-half the pupils were fixed to light; an additional 23.8 per cent were sluggish in reaction.

The author concluded that the pupils may aid in the diagnosis of comatose states when such states result from trauma of the brain, but are of little or no diagnostic importance when the coma is due to alcohol poisoning, diabetes, uremia or carbon monoxide.

HART, Greenwich, Conn.

EXPERIMENTAL ANATOMIC STUDIES ON THE VISCERAL BULBOSPINAL PATHWAY IN THE CAT AND GUINEA-PIG. W. F. ALLEN, J. Comp. Neurol. **42**:393 (Feb.) 1927.

Marchi preparations were studied in cats and guinea-pigs following lesions which involved different portions of the nucleus tracti solitarii. Through a study of the distribution of degenerating fibers of the tractus solitarius in a Marchi series of a guinea-pig, the position and boundaries of the nucleus of this tract were determined. Lesions involving only the nucleus were not followed by degenerated fibers in the spinal cord, but when deeper incisions included the formatio reticularis, degenerated fibers were found in both anterior columns of the spinal cord. Physiologic observations are given which indicate that the medullospinal respiratory impulses are conducted chiefly in the ventral part of the lateral columns and in the lateral part of the anterior columns. It

was found that total destruction of the spinal medulla and trigonum vagi portions of the nucleus did not produce a greater permanent injury to the respiration of the guinea-pig and cat than did severance of both vagus nerves.

Nissl studies of the larger cells of the caudal halves of the solitary tract nuclei of a normal inactive cat and guinea-pig revealed in equal proportions three types: normal resting or inactive type, fatigued or physiologically chromatolytic type (includes a few cells of the vacuolated or honeycombed variety) and the active type. The cephalic portion of the nucleus contained chiefly the resting type.

Following experiments on fatigue the caudal halves of the solitary tract nuclei possessed cells almost entirely of the chromatolytic type. Animals in which the spinal cord was more than hemisected at the level of the fourth cervical vertebra or lower showed cellular conditions in the solitary tract nuclei similar to those found in the nuclei of normal inactive animals. It is therefore concluded that chromatolytic cells in solitary tract nuclei following such hemisected cords are produced from fatigue rather than from severance of their axons. It is further concluded that the solitary tract nuclear cell in a solitary spinal reflex relays stimuli to a cell of the formatio reticularis and the latter in turn to a motor cell in the spinal cord.

STONE, New Haven.

A STUDY OF THE REFLEX TIME OF THE KNEE-JERK AND THE ACHILLES-JERK. W. W. TUTTLE, L. E. TRAVIS and T. A. HUNTER, Am. J. Physiol. **82**:99 (Sept.) 1927.

In this article the time relations of the patellar and Achilles reflexes are presented. These studies were carried out on a series of eight normal male subjects and included inquiry not only as to gross reflex time, the period between the delivery of the stimulus and limit displacement for the knee jerk only, but also as to the reduced reflex time, the period between stimulus impingement and the setting up of the consequent action current. The electrical changes were detected by means of a five stage amplifier and were phonelescopically recorded. The authors found the average reduced reflex time for the knee jerk to be 0.0194 seconds (range from 0.0105 to 0.0325) and the average gross time 0.0796 seconds (range from 0.0557 to 0.1094). There was not any correlation determined, however, between gross and reduced times, apparently largely because the stimuli applied were not altogether uniform. The average reduced time for the Achilles jerk was determined as 0.0347 seconds (range from 0.0251 seconds to 0.0381 seconds) which is distinctly greater than for the patellar response, a relation noted consistently with all subjects. Much of this difference it is believed may be ascribed to variation in the neural mechanisms specifically involved. The authors conclude from this fact and from the marked ranges observed for the individual responses that both these reactions are of truly reflex nature and are not simply local muscular phenomena. Also in favor of this conclusion is the observed periodic nature of the action currents which is not explainable as of muscle origin. Suggestion is likewise made of the possibility that the reflex pathway in both types may involve much more than a simple spinal arc from the wide reduced time ranges found for the same subject and on the basis of the commonly noted influencing effect on the knee jerk of various extrinsic or environmental influences.

RAPHAEL, Detroit.

MEDULLARY AND PONTINE SYNDROMES. RUBIN A. GERBER, J. Nerv. & Ment. Dis. **66**:355 (Oct.) 1927.

The author gives case histories of a number of medullary and pontile lesions illustrating the more common clinical syndromes. The article is essentially a review of those that are more important. The pons is a favorite site for foci of softening, and not so much for hemorrhage. Encephalitis and dis-

seminated sclerosis also frequently affect the pons. The basilar and vertebral arteries are comparatively often occluded by a thrombus due to arteritis, atheromatous or syphilitic. The posterior inferior cerebellar artery is the one most frequently affected. Constriction due to arteriosclerosis may impair the circulation and cause symptoms. Loss of consciousness is not always an accompaniment of pontile hemorrhage. Simulation of pontile and medullary syndromes may often be produced by extracranial disease through syphilitic, tuberculous and neoplastic adenopathies. Pharyngeal abscess may produce similar pictures. Collet and Sicard have described a glossolaryngoscapulopharyngeal hemiplegia, due to lesions of the posterior lacerated foramen. Tumors of the medulla are rare, and the symptomatology is often indefinite, but a minute analysis of the order of nerve involvement is important. Early paralysis of the third and sixth nerves due to intracranial pressure is explained by their medial emergence, and other cranial nerve involvement is necessary to determine the localization. Irritative symptoms may be present, usually in the form of hyperesthesia and root pain in the area of the tregeminal. The third, sixth and seventh nerves are most frequently involved in gummatous tumors and tuberculous deposits at the base of the brain. Cerebellar irritative phenomena may be observed as distant effects of pontile lesions.

H. H. Hart, Greenwich, Conn.

A Study of the Bulbo-Spinal Reflexes in Dogs and Cats Under Barbital Anesthesia. J. F. Pearcy and M. M. Weaver, Am. J. Physiol. **82**:47 (Sept.) 1927.

The authors report interesting neurophysiologic observations on dogs under barbital anesthesia. They find that effective surgical anesthesia may be induced in adult dogs of average size by 0.3 Gm. per kilogram by mouth, 0.27 Gm. intramuscularly or intraperitoneally, and from 0.20 to 0.25 Gm. intravenously. The dosage required is somewhat less than this standard, however, for small dogs and is greater for especially large subjects. Likewise, smaller amounts are sufficient for young and old dogs and less is needed for cats than dogs. Satisfactory anesthesia follows in from thirty to sixty minutes after administration by mouth, from twenty to forty minutes after intramuscular or intraperitoneal administration, and from ten to twenty minutes after intravenous injection. The authors themselves prefer the intramuscular procedure. In these preparations the bulbospinal reflexes are practically undisturbed over a more or less indefinite period, with temperature and pressure relations remaining normal for as long as from twenty-four to thirty-six hours. Also after cord transection in such animals, "spinal shock" is delayed in some instances half an hour or more. On the whole these barbitalized subjects are believed to be fully equal for the purposes of study, if not superior to actually decerebrated animals; at the same time they obviously represent much simpler and more certain preparation problems. It is largely with this point in mind apparently that the present paper is reported.

Raphael, Detroit.

The Transplanation of the Medulla Oblongata into the Brachial Region of the Cord in Amblystoma Embryos. S. R. Detwiler, J. Comp. Neurol. **43**:143 (April) 1927.

In this paper Detwiler has continued his studies on the development of various portions of the embryonic neural tube grafted into new regions and has studied further the effects of the graft on adjoining nerve tissue. The embryonic medulla was substituted for the fourth, fifth and sixth spinal segments in *Amblystoma* (salamander). This is partially in the region from which the brachial plexus develops. A graph is shown which indicates that the extent of the cellular proliferation throughout the transplanted medulla corresponds closely to that which normally characterizes the segments which have been

replaced. A previous publication (*J. Exper. Zool.* **41**:293, 1925) had shown that a much higher proliferation was attained when the anterior end (first three segments) of the spinal cord was substituted in this same region. The point is emphasized that the inherent capacity for cellular proliferation is greater in the anterior end of the cord (caudal end of medulla to third spinal segment) than in the medulla itself when grafted to the brachial region.

Limb reflexes were also studied, and no case was found with perfect function of the limb. In some cases movements of the limb were only slightly restricted; in others they were much restricted. These defects were correlated with specific insufficient peripheral innervation rather than with central defects.

STONE, New Haven.

MUMPS POLYNEURITIS; QUADRIPLEGIA WITH BILATERAL FACIAL PARALYSIS. W. S. COLLENS and MEYER A. RABINOWITZ, Arch. Int. Med. **41**:61 (Jan.) 1928.

After briefly reviewing the only four cases of diffuse polyneuritis found in the literature — those by Joffroy, Revilliod, Gallavardin, and Pitres and Marchand, the authors cite a case of their own. A man, aged 29, suffered a mild attack of epidemic parotitis which was followed by orchitis and testicular atrophy. Three weeks after the onset he complained of weakness in the lower extremities, which was followed within forty-eight hours by almost complete paralysis of all four extremities and difficulty in swallowing. Within one week after this, regression of symptoms set in; but it was nearly five weeks after the onset of the paralysis before the patient could sit up voluntarily without support. On the sensory side there were paresthesias and loss of joint and vibratory sensibility in both arms and legs. Ultimately, complete recovery occurred some three months after the onset. The authors consider that the presence of meningeal symptoms, absent abdominal reflexes and predominance of motor phenomena indicate some involvement of the cord in addition to the peripheral neuritis.

ANDERSON, Philadelphia.

THE PREVENTION OF TETANY BY ORAL ADMINISTRATION OF MAGNESIUM LACTATE. W. F. WENNER, Am. J. Physiol. **81**:392 (July) 1927.

This study was carried out on a series of ten thyroparathyroidectomized dogs fed postoperatively on a Cowgill diet and given 300 cc. of 5 per cent magnesium lactate by mouth daily. Wenner found that magnesium given in this way represents an extremely effective tetany prophylactic and therapeutic. After forty days of such treatment, the magnesium could be withdrawn with fair expectation of permanent recovery and capacity on the part of the animals to return safely to a full meat diet. The sedative influence of magnesium is also helpful, when tetany has developed, in controlling its more violent manifestations. The effect of the magnesium probably depends on its ability to maintain the serum calcium content above the "tetany level," this being made possible apparently by the retention of the calcium in the solution through the union of the magnesium with excess phosphorus. Calcium, sodium and potassium lactates were likewise utilized, but failed to demonstrate any tetany preventing effect.

RAPHAEL, Detroit.

CLINICAL CONTRIBUTIONS TO DRUG ADDICTION. LAWRENCE KOLB, J. Nerv. & Ment. Dis. **66**:22 (July) 1927.

The relapse of drug addicts is due mainly to the same cause that is responsible for the original addiction, namely, a pathologic nervous constitution with its inferiorities and pathologic strivings from which narcotics give an unusual sense of relief and ease. The inebriate impulse, the desire for dissipation, is one of the most important causes of relapse. Relapse is more common than formerly because the addiction of more normal, and therefore more easily

curable persons is less common. Nearly all addicts make sincere efforts to be cured during the early period of addiction. Many of the cures taken later are mere matters of expediency and are insincere in effort. The hope for cure wanes as time passes and the force of habit, numerous impelling memory associations and increasing physiologic dependence on opiates are added to the original nervous pathology. Physical dependence on opiates is unimportant as a cause for relapse during the first two or three years of addiction in those addicts who have not used the drug for two weeks or more. In some very nervous persons who have been addicted to opiates for many years, withdrawal of the drug may produce hysterical symptoms or hypomania lasting for several months.

HART, Greenwich, Conn.

THE TETANIC NATURE OF THE KNEE-JERK RESPONSE IN MAN. L. E. TRAVIS, W. W. TUTTLE and T. A. HUNGER, Am. J. Physiol. **81**:670 (Aug.) 1927.

The authors used twelve normal male subjects in these studies, the action currents developed as a result of patellar stimulus being detected by means of a five stage amplifier and recorded phonelescopically. In all cases it was found that periodic discharges occurred within the latent period of the reflex, thus demonstrating this reaction as tetanic and not as a "simple muscle twitch." Further, it was determined that the electrical changes developed in movements of voluntary type are more or less the same as those characteristic of reflex reactions. The authors also suggest, since both audible and inaudible frequencies were noted in the patellar action current records, that two or more centers of discharge may be concerned in the mediation of this reflex response, although as to their locale at this time no statement is possible.

RAPHAEL, Detroit.

CONGENITAL HEREDITARY ONYCHOGRYPOSIS, TOTAL ALOPECIA, AND SCHIZOPHRENIA. MAX SCHMIDT, Acta Psychiat. et Neurol. **2**:317, 1927.

An extremely interesting family group is described, of which two members constitute the immediate material. These are sisters presenting a pronounced leptic bodily structure; with onychogryposis of all fingers, generalized alopecia, and mental symptoms indicative of dementia praecox. A chart traces the heredity back to the great grandparents of the patients; one of these ancestors (male) had onychogryposis. The F generation had four members, of whom three were definitely affected; the F_2 generation had ten; in the F_3 generation (that of the patients) there were seventeen of forty-two who were known to have onychogryposis. The literature is reviewed, and the article includes a discussion of the possible related condition of "blue sclerotics."

ANDERSON, Philadelphia.

EMOTIONAL INSTABILITY OF COLLEGE STUDENTS. J. W. BRIDGES, J. Abnorm. Psychol. **22**:1 (Oct.-Dec.) 1927.

Students are perhaps more unstable than the average of the general population. This is more true of women than of men, and of art students than of medical students. The symptoms are those found in an anxiety neurosis. Emotional instability is compatible with high intelligence and scholarship. The article strongly suggests the need of mental hygiene in college groups.

HAMILL, Chicago.

Society Transactions

BOSTON SOCIETY OF PSYCHIATRY AND NEUROLOGY

Regular Meeting Nov. 17, 1927

HENRY R. VIETS, M.D., *President, in the Chair*

THE USE OF INTRAVENOUS SALICYLATE IN EPIDEMIC ENCEPHALITIS. DR. STANLEY COBB and DR. SAMUEL EPSTEIN. Presented by DR. EPSTEIN.

At the November meeting of this society a year ago, Dr. Maxwell MacDonald read a paper on therapy in Parkinson's disease and mentioned the use of sodium salicylate. In this paper we will give a brief résumé of the history of this form of therapy and report the results in a group of patients treated intravenously with sodium salicylate at the Boston City Hospital during the past year.

The original work with salicylates was done in Paris, in 1923, by Carnot, who treated two patients who had acute epidemic encephalitis by intravenous injections of sodium salicylate. One patient recovered almost completely after a week of daily injections and then relapsed when the injections were discontinued. The second patient showed excellent results under continued treatment by injections. In the same year, Barry, in a comprehensive study of various therapeutic agents in epidemic encephalitis, reported ten additional cases in which patients were treated with sodium salicylate intravenously with marked clinical improvement in nine. Furthermore, he pointed out the striking parallelism between the institution of salicylate treatment and the amelioration of symptoms, and conversely a recrudescence of symptoms when the injections were discontinued. Barry also mentioned the experimental work of Carnot and Harvier in successfully neutralizing in vitro the encephalitic virus by contact with sodium salicylate. Many other isolated cases of acute epidemic encephalitis treated with sodium salicylate intravenously have been reported, especially in the French literature. While Carnot and other authors suggested that salicylate therapy would be worth trying in cases of chronic encephalitic parkinsonism, few cases have been reported in the literature. In 1924, Vedel, Puech and Pages of Montpellier reported six cases, with definite relief in one case, questionable improvement in another and no relief in the remaining four. In 1925, MacBride and Carmichael reported three cases in London; in two of them, the ability to write a legible hand returned, and the rigidity was definitely reduced. The mode of administration of the drug has been described in detail by previous workers. Intramuscular, oral and intraspinal methods were used in addition to the intravenous route. The dosage and dilution varied widely.

In our series of cases, a constant dosage of 2 Gm. of sodium salicylate contained in 10 cc. ampules (20 per cent solution) was injected intravenously at weekly intervals. An exception occurred in one case, that of E. M., in which 2 and 4 per cent solutions were employed. The results in these cases are briefly indicated in the accompanying table. Two cases of paralysis agitans (nonencephalitic, J. O. and J. M.) and one case of multiple sclerosis (B. D.) in which the patients were treated intravenously with sodium salicylate are also reported in the accompanying table.

It is apparent that these patients received little or no benefit from salicylate therapy. Of the twelve patients with chronic encephalitic parkinsonism, only three appear to have been improved by the treatment, and in them the improvement was temporary. The improvement in the two patients with nonencephalitic paralysis agitans was also temporary. Some subjective relief was noted in nearly every patient, but the psychic element was probably large. The progression of

parkinsonian symptoms does not seem to have been arrested appreciably. One case (that of H. J.) illustrates that the disease progressed in spite of salicylate therapy. Local venous thrombosis, as noted by the French, occurred at one stage or another in every case. This could be avoided by giving the drug by mouth, and it would seem that frequent large doses given by the oral route might be more effective than weekly intravenous doses because of their greater continuity of action. The rationale of salicylate therapy in acute and chronic forms of encephalitis is not clear. Whether it is a specific or general anti-infectious agent is not known. It probably has been effective in some acute cases reported by the French. Judging from the evidence in the literature, it seems that salicylates benefit patients with acute epidemic encephalitis. From the evidence presented in our series of cases, it appears that chronic encephalitic parkinsonism is not benefited by salicylate therapy. Since, however, this disease is now generally considered as a chronic stage of acute epidemic encephalitis, it is possible that persistent treatment by salicylates during the acute stage and long after the acute symptoms have subsided, may prevent the development of parkinsonian symptoms.

Cases at the Boston City Hospital in Which Salicylates Were Used

Case	Sex*	Age	Acute Began		Chronic Parkinson Treatments			Relief
G. F.	♂	20	"Influenza"	1920	1924 – March	1927	7	No
T. R.	♂	29	Epidemic encephalitis	1922	Jan.	1927	15	No
B. K.	♂	26	Lethargy	1925	Aug.	1926	17	No
A. F.	♀	40	"Influenza"	1918				Less pain
					April	1927	13	
			Lethargy	1919				Less stiffness
J. F.	♂	40	Epidemic encephalitis	1922	Aug.	1924	10	No
E. M.	♀	40	"Influenza"	1923	June	1925	8	Temporary
E. K.	♀	23	Epidemic encephalitis	1922	Aug.	1927	6	No
J. S.	♂	42	"Fever"	1917	Nov.	1925	4	Slight
H. J.	♂	24	"Influenza"	1918	1921 – March	1927	8	No
E. J.	♀	44	"Grippe" 1	1923	April	1925	13	No
M. H.	♀	44	"Influenza"	1918	1926 – March	1927	8	No
F. J.	♂	15	Epidemic encephalitis	1920	July	1927	3	No
J. O.	♂	61	.....		July 1925		9	Temporary
J. M.	♂	62	.....		July 1925		10	Temporary
B. D.	♂	27	Multiple sclerosis				19	No

* In this column, ♂ indicates male; ♀, female.

DISCUSSION

DR. STANLEY COBB: We have been trying this treatment now for about a year and it is obviously unsuccessful. The literature suggests that it is of use in acute cases. We have had no experience with these cases so we have no opinion. I do not believe that we have had any real cases of encephalitis in the last year. I am interested to know if any one has had any proved acute case recently. We have a patient in the hospital now who may have an acute case of encephalitis.

DR. E. W. TAYLOR: You mentioned acute cases of encephalitis in France in which there was distinct improvement. Can you give in more detail how definite the improvement was and in what way it was shown? I am also interested to know how persistent it was.

DR. SAMUEL EPSTEIN: The French have shown a regular sequence of events following salicylate therapy in acute cases of encephalitis: the infectious signs disappear; then, neurologic signs, restlessness, myoclonic movements and headache. The cases were not followed for long periods after the acute stage; therefore, it is not known whether the patients eventually developed parkinsonism. They received daily injections of sodium salicylate for weeks—sometimes for months—and when discharged from the hospital were apparently well. The experimental work done by Carnot and Harvier is interesting. Two rabbits were inoculated on the same day with encephalitic virus, one with the virus alone and the other with the virus in contact with a solution of sodium salicylate. The latter animal survived; it was again inoculated with encephalitic virus and again survived. Another experi-

ment was performed on four rabbits. The first was inoculated with the virus alone and died on the fourteenth day. The second was inoculated with the virus and at the same time was treated with injections of salicylate; this animal also died on the fourteenth day. The third was given prophylactic injections for two days before inoculation; this animal died on the thirtieth day. The fourth was treated with salicylates for four days before inoculation and for the following twenty days. This animal died on the fifty-fifth day, but, it was claimed, not of encephalitis, since another rabbit inoculated with the virus from that animal survived.

DR. COBB: I do not believe that experimental work on encephalitis in rabbits has any validity. The work quoted by Dr. Epstein must be taken as not proved.

DR. EPSTEIN: We had a case at the Boston City Hospital last summer which presented a typical clinical picture of acute epidemic encephalitis. The patient died, but a postmortem examination was not made.

A CASE OF CEREBELLAR APLASIA IN A CAT. STANLEY COBB, M.D.

History.—The kitten was born about April 4, 1926, one of a litter of three. The parents and siblings were all normal. No illness was noted, except one day of refusing food, during the first days of life. As soon as he began to walk the peculiar gait was observed; this did not increase with age. It was noticed that the asynergia was worse after rest, and coordination improved with exercise. Once this animal was seen to rush 40 feet after a rat and kill it. Early in August he was seen by Mr. S. Ellis, who observed him for six weeks and brought him to the Harvard Medical School on Sept. 16, 1926. During these six weeks, change in symptoms was not observed.

Physical Examination.—(Drs. Cobb and Schaltenbrand, October, 1926.) The kitten was an alert, affectionate male, weighing 2.55 Kg. and of rather short stocky build, fat and with a good coat.

Station: He stood on a broad base, especially with the hind legs. The lower dorsal and lumbar spine was always arched. When standing there was a fine, constant tremor of the neck and head; the shoulders were also unsteady.

Gait: Asynergia of the hind legs was extremely marked; in moving they were widespread, somewhat everted and did not coordinate with the front legs. It seems as if the shoulder girdle was rather stable; the pelvic girdle and appendages overrunning the forelegs at times made the animal swing to the side and stumble. In walking, the hind legs appeared slightly spastic. When lying on the side, the cat could use the forelegs accurately to strike at a moving object. In climbing, the hind legs were scarcely used at all, the body being pulled up by the forelegs. When blindfolded the animal became much more unsteady.

Reflexes: knee jerks were active, right slightly greater than left(?); labyrinth righting reflex quick and normal, even when the animal was blindfolded; tail reactions strong during walking; neck righting reflexes present on both sides; body righting reflexes were weaker than normal, at times almost absent; turning reactions (while falling two feet) were weaker than normal; the cat would fall on the side; movement reactions were all normal, that is, the turning reaction of head and eyes, the elevated reactions, and the "Sprungbereitschaft"; flexion reflex of legs was normal; crossed extension of legs was normal.

Sensory: Perception of pain seemed to be reduced over the whole body; the animal reacted little to prick, pinch or heat.

Course.—During October, November and December, the animal was extremely strong, gained in weight, and looked sleek and healthy. He was mated with four wives and produced twelve young. These were watched with care for signs of inherited asynergia, but, although some of the kittens staggered a good deal in youth and aroused great hopes, they either outgrew this or died and showed normal brains. During February, March and April the animal developed mange and began to lose weight. He staggered more as he became weaker, but the symptoms remained essentially the same. During May he lost weight rapidly, but retained a large belly; he grew weaker and died on May 13, 1927.

Autopsy.—(May 13) Examination of the body showed no cause of death, except dermatitis and emaciation. The bones were rather soft; lack of sunshine and rickets may have been a factor. The brain was hardened in 10 per cent formaldehyde of 40 per cent strength.

Comment.—Moving pictures brought out fairly well, even in their brief course, the abnormality in station, the tremor of the neck and head, and the marked asynergia of the hind legs. Moreover, they showed that the animal when lying down was able to use its forelegs with good accuracy and that in spite of the asynergia he was able to run and romp about in a fairly effective way.

The brain was sectioned, and a brief study of the microscopic preparations did not show any abnormality in the cord; in the medulla, however, there was a distinct lack of development of the principle olivary nucleus, whereas the accessory olivary nuclei, especially the inferior ones, were well developed. Proceeding upward in the hind brain, one found that the cerebellum was distinctly aplastic and symmetrically small in all dimensions, and had a distinctly simplified lobular arrangement. I have not, as yet, worked out the exact anatomy of this abnormal cerebellum, but the general appearance indicated that it was the median lobe (according to Ingvar) that was aplastic. This impression was strengthened by the fact that the pons was extremely small. Moreover, the section of the cerebellum which goes through the nuclei showed that, while the roof nuclei were well developed, the dentate nuclei were not so conspicuous.

This evidence suggested that we were dealing with an aplasia of the neocerebellum in a cat. This case is interestingly similar to one which was presented to this Society last year by Professor Brouwer of Amsterdam.

A Case of Pinealoma with Symptoms Suggestive of Compulsion Neurosis. Clinical Report: Dr. Percival Bailey. Psychologic Report: Dr. H. A. Murray.

Clinical Report.—An Italian boy, aged 15, applied for medical care to the outpatient department of the Massachusetts General Hospital on Nov. 3, 1924, complaining of indigestion, constipation, loss of appetite and a tendency to vomit. He said that he had had to take castor oil since the age of 7 but that for the last two months it had failed to have any effect. He also said casually that he drank large quantities of water and was always thirsty.

Physical examination did not reveal anything abnormal. He was placed on a diet and told to return with a twenty-four hour specimen or urine. He returned the next day with three gallons, and was advised to enter the hospital. He was admitted to the Boston City Hospital on Nov. 28, 1924. There he said that for two and one half months he had suffered from thirst and frequent urination, had lost his appetite, and usually vomited on arising in the morning. He also remarked that he had had occasional attacks of vomiting since the age of 5 or 6.

Physical Examination.—The boy was tall, thin, rather sallow and emaciated, but did not present other abnormalities. At this time, he usually passed about 10 liters of water daily with a specific gravity of from 1.000 to 1.003; sugar and albumin were not found. The spinal fluid was found at lumbar puncture to be under a pressure of 270 mm. of water. The roentgen ray showed a normal sella turcica. The basal metabolic rate was —26.

Course.—He was given pituitrin, 2 cc. subcutaneously, daily. The intake of fluid dropped considerably, but there was little influence on the output. The effect on the intake was only transitory, and he lost weight gradually. On December 18, he developed a swelling on both sides of the face in the region of the parotid glands. This swelling rapidly subsided, and he was discharged from the hospital on December 28 with his condition practically the same as on entrance, except that he had lost some weight.

He entered the Peter Bent Brigham Hospital on Feb. 6, 1925. Since his discharge from the Boston City Hospital, he had been drinking from 4 to 8 gallons of water a day. Examination at this admission disclosed nothing abnormal, with

the exception of emaciation and general weakness. Examination of the eyegrounds showed the fundi to be normal. Roentgen-ray examination of the head disclosed a shadow in the region of the pineal body and a normal sella turcica. It was difficult for him to retain any nourishment because of frequent vomiting unaccompanied by nausea. He had also abdominal cramps. He was given pituitary without much effect, there being only a slight reduction of the intake even when he was given 1 cc. of surgical pituitary three times a day subcutaneously. A lumbar puncture was performed on February 9, and 5 cc. of colorless fluid was obtained under low pressure which contained 5 cells per cubic millimeter. The globulin test was negative, and the colloidal gold reaction was 1100000; the Wassermann reaction was negative both in blood and spinal fluid. He was discharged from the hospital on April 17.

Two days later, he returned. Friends of the patient's mother had made her believe that the son had a tapeworm, so on the afternoon of his discharge from the hospital she gave him a large dose of "Dr. True's Elixir" and probably also other medicines, although she was rather reticent on this point. On the next day, she gave him a large dose of magnesium sulphate, and on the third day another large dose of magnesium sulphate and an enema, in the course of which he collapsed and was brought to the hospital. He was discharged on April 21 as soon as he had recovered from the effects of the ill advised medication.

After discharge, he discontinued taking pituitary and voluntarily limited the intake of water, as he says by will power. He was doing fairly well until July 15, 1926, when he was struck on the head and beaten by a drunken policeman. He was taken to the Boston City Hospital where no internal injuries were found, but since that time he had vomited practically every day and complained of a dull pain in the epigastric region.

He entered the Brigham Hospital in the surgical service on Aug. 6, 1926. At this time he was greatly emaciated, having lost 20 pounds (9 Kg.) in weight; otherwise, no abnormalities were found except that there was slight tenderness on pressure in the epigastric region, and the skin was dry and scaly. It was then noted in the history that he probably had an internal hydrocephalus, and that he resembled closely another patient, who had been in the hospital some time previously with a tumor of the third ventricle and another of the pineal body.

A ventriculogram was advised but not done because of the opposition of the patient and the belief of some members of the staff that the troubles were largely functional. The basal metabolic rate at this time was —20; the weight was 68½ pounds (Kg. 30.8). He was transferred to the medical service on Aug. 11, 1926.

At this time, the intake of fluid was from 3,000 to 4,000 cc. daily. A phenolsulphonephthalein test was made with 150 cc., of which 52 per cent was excreted in two hours and ten minutes. He was transferred back to the surgical service on Aug. 23, 1926, for a ventriculogram. He was prepared for the operation but created such a disturbance that the attempt was abandoned and he was discharged on August 25.

He went at once to the Massachusetts General Hospital, where he was admitted to the neurologic service on August 26. A note was made that: "Glands can be felt in the abdominal region under the cecum, and I think it is tabes mesenterica." On September 11, a lumbar puncture was done and 15 cc. of clear colorless fluid were withdrawn; examination revealed: 15 lymphocytes, protein 39, colloidal gold curve 1121000000 and a negative Wassermann reaction. On September 14, it was noted that there was not any evidence of an intracranial lesion. On September 18, another lumbar puncture was done; examination showed: 18 cells, protein 53 and colloidal gold curve 2222110000. The basal metabolic rate was —20. An attempt was made to reduce the fluid intake by pituitary without effect, the intake at this time being about 4,630 cc. daily. On September 19, it was noted that "lumbar puncture observations were abnormal and that there must be an organic lesion, the location and nature of which were not evident." On September 25, he developed swellings of the parotid glands and of the lips accompanied by a burning sensation. On that day he passed 2,500 cc. of urine between 7 and 11 a. m.; a

lumbar puncture done at this time gave again an abnormal fluid: 21 cells, one of which was a large mononuclear and the others lymphocytes; sugar, 44; chlorides, 725; total protein, 44; colloidal gold curve, 1221000000. After October 2, he was not given pituitary since it seemed to have no effect. On October 3, it was noted that angioneurotic edema seemed to explain a large part of the clinical picture, and the case was reported from this standpoint in the *Boston Medical and Surgical Journal* (**195**:1029 [Nov. 25] 1926) by Dr. Francis T. Hunter as being a case of vomiting and polydipsia from an unusual cause. On October 15, the basal metabolic rate was — 16; he was becoming more and more emaciated, and ate little because of constant nausea and vomiting.

On October 19, it was noted that neurosis played a large rôle in the trouble, and hypnosis was suggested as a therapeutic measure. In the meantime, tube feedings were resorted to in the attempt to make him gain weight. On October 29, it was noted that the etiology might well be psychogenic and that the symptoms in general indicated a vagotonic disposition: "It is convenient, I think, to divide the patient's symptoms into two somewhat independent processes: (1) polydipsia and subsequent polyuria, an internal cleansing action associated with a sense of sin; (2) vomiting, nausea, anorexia and other symptoms mostly referable to the parasympatheticonia associated with fear or disgust with self." On Dec. 13, 1926, he was discharged to go to a nursing home. He was there subjected to psychologic examination and treatment.

Psychologic Report.—Many modern philosophers and scientists see in the recent advances of physics the possibility of a reconciliation of Descartes' original dichotomy of mind and body, and are looking with favor on theories that regard mind and matter as two aspects of the same process. It is not for psychiatrists to neglect such questions. Psychoneurology is in an empirically strategic position, and the present case is an example of the type of datum which is relevant to this age-old problem. In the minds of some neurologists, this report may appear to be the final refutation of all psychologic hypotheses about such cases, because in this instance some of what have come to be recognized as the chief factors or complexes underlying the psychoneuroses are manifested in obvious and unequivocal terms—conduct of a symbolic or conditioned nature following an incestuous act; the edipus situation and the struggle for power; then a marked improvement with psychotherapy, and at the end, sudden death.

As is usual in such cases the psychologic history would make a memoir, but as there are no really complicated episodes, this case lends itself readily to summary form.

It is noteworthy, that the most persistent set of symptoms — anorexia, vomiting and constipation — were more or less chronic throughout life. As a small child, he had had frequently recurrent attacks of indigestion, and since then the gastro-intestinal system seemed to be the weakest link in the total physiologic economy. His taste for food was marked by peculiar idiosyncrasies. The tendency toward early morning anorexia and vomiting, moreover, was a physiologic disposition shared by the mother; she rarely ate breakfast.

The family situation was significant. The boy was the second child and the first son in a family of six. The oldest, a girl, found the conditions at home intolerable and finally departed to live with relatives, leaving the patient in an apical position. The mother, a Florentine by birth, was a pleasant but fretful housewife. She talked incessantly and nagged her husband and children until the summation of impulses produced an explosion. At times, the husband acted in an extremely brutal fashion, and on one occasion spent three months in a reformatory for beating his wife. His personality and disposition are of interest. In 1926, he, a Sicilian by birth and a barber, was 46 years old. He was short and mild in appearance, but on provocation could become extremely fiery and aggressive. Experience had taught him that his fault-finding wife was the most rage-provoking object in the external world. He said that the three months he spent in the reformatory were the most pleasant of his marital career. His habits were good; he did not drink, did not seek

other women and gave all his wages to his wife. At home he did as little work as possible, and was extremely arbitrary and critical. His attitude was characterized chiefly by a stubborn resistance to all calls to exert himself and by an overbearing dictatorialness.

In temperament the boy resembled the father in many respects. On the surface he was gentle and amenable, but on occasion could be extremely stubborn and insistent. He had, however, no liking for the father, and from an early age sided with the mother, who treated him with indulgence when she was not fretting him with small duties. He had cause for indignation at the father's behavior and for anxiety over the mother's welfare. The boy was much at home and helped his mother with her domestic duties. He always tried to defend her when the father flared up in a tempest.

Aside from any deeper affinities and hostilities, it is evident that there was good cause for the eldest son, who was proud and idealistic, to regard his napoleonic father as a natural antagonist and his warmhearted mother as the object of chivalrous devotion. In the early days, he had a profound fear of the father, but later he claimed that he had outgrown it.

As regards water-drinking, the boy's most dramatic symptom, it is interesting to note two circumstances: 1. When asked for his earliest remembrance, the boy told that as a child he had set out with some older boys to bring some water for his mother from a spring some distance from his home. The companions ran ahead, leaving him to trudge along disconsolately alone. When he reached the spring, the boys teased him for some time by preventing him from drinking or filling the bottle for his mother. He wept bitterly and felt a deep humiliation. In this story and in the relations with the father there is, according to the adlerian principles, the core of a feeling of inferiority and of masculine protest. It is perfect; all the elements are present: an errand for the mother; the search for water; defeat and shame at the hands of the gang.

2. The mother had taught all her children to drink a glass of water whenever they were frightened. If the boy came running home after being chased by a dog, she would say: "Quick, drink a glass of water." It was her antidote for fear, and it became the "meaning" of water to her son.

Although the boy had many illnesses in childhood, the present condition did not commence until the winter of 1924, when he suffered from asthma and bronchitis, or more specifically until June of the same year when the real symptoms commenced: (1) anorexia, nausea, vomiting and constipation; (2) polydipsia and polyuria, and (3) dry mouth with an insistent need for washing it out.

At the time when the illness commenced the boy was considered by the parents to be obedient and industrious. He was of average intellectual ability and had just finished the second year at English high school. With the progress of the illness, however, the disposition changed. He became alternately apathetic, restless, intractable or rebellious.

Two and one half years after the onset, after a thorough examination by numerous specialists at the Massachusetts General Hospital and when it was settled that pituitary had little or no effect on the polydipsia, it was suggested that the boy's condition might be psychoneurotic. The staff had noticed: (1) that the mere passage of the stomach tube had seemed to increase the appetite and to stop temporarily the vomiting; (2) that he was unreliable and stole water and ice cream cones whenever he could do so; (3) that he became sick when he could not have his way; (4) that he was encouraged in these practices by the mother, and (5) that in many lesser ways he showed the earmarks of chronic professional invalidism.

On Nov. 1, 1926, Dr. Herman handed the patient over to me for examination and treatment. He was excessively emaciated and, although, aged 17, weighed only 60 pounds (27.2 Kg.). He was lying prostrate in bed, refusing to eat and calling incessantly for water. He was drinking up to 14 liters a day (30 pounds [13 Kg.], or one half his body weight). Complete anorexia and the

habit of vomiting everything that he ate or that was forced by tube into his stomach had brought him to the verge of starvation.

He seemed to be intelligent, with good reasoning ability. On first appearance he seemed affable and cooperative; he understood readily and promised to do what was asked of him, but when left to himself he seemed ruled by some inherent perversity of character that led him to do things which had no significant purpose either for himself or for others. Negativism was the most pronounced characteristic of his conduct. He claimed to be especially attached to his mother and at times did show a sympathetic interest in her welfare, but as a rule he was mutinous, surly and opinionated. A streak of latent cruelty was evident. He formed no personal attachment for nurses or physicians. In these respects he approached the antisocial or criminal make-up. The water drinking really came from thirst, he said. He remembered feeling thirsty all through the summer of 1924. It was much like an addiction, but it was very inconvenient. He could not go to sleep without water; had to go to the toilet on the top floor to get it; he hated to disturb his mother and father. "Gee whiz, I don't want to do this — but I have to do it," he would say.

When asked why he had started drinking water in 1924, he said: "To clean out my urine. I thought that if I drank a lot it would get it all clear and then I wouldn't have to drink any more." When this was probed further, it turned out that it was about this time that he was taught to masturbate. Because he was idealistic, he took it as a serious crime and stopped a few weeks after he had begun. It was to this circumstance that he referred when he spoke of "clearing out his urine." Strangely enough, the onset of his symptoms seemed to stop the normal development of the sexual system. He ceased having erections, and up to the time of death at 18 years of age he had not had nocturnal emissions.

Another incident of importance happened about this time. He was badly defeated after a long fight by the leader of another gang. He was hurt considerably and shamed. Immediately after the fight, he remembered going to the nearest fountain and drinking water copiously.

The course of the boy's symptoms progressed for the following year as outlined in the clinical report. In the summer of 1925, the father was sent to the reformatory, and the boy started to improve immediately. The weight rose to over 100 pounds, and he procured a job. A few days before the father returned home, the boy's symptoms returned, and he was forced to give up his work. In connection with what has already been said about the boy's lifelong feud with the father, this item seems to be of importance.

Later, he again started to improve, and continued to do so until July, 1926, when all the symptoms returned after chastisement at the hands of a policeman. It was a severe defeat and reminiscent of the "licking" in 1924 when the illness commenced. This time he was knocked unconscious and was taken to the City Hospital. From that time on his appetite failed, and he vomited regularly every morning until three months later, when he reached the state of almost complete collapse in which I found him.

The facts just related and many others of a similar character were unfolded in the first few talks we had together. For some reason that I cannot fathom, he immediately commenced to improve. Within a week, the water was reduced to a normal supply, three or four glasses a day, and the frequency of vomiting and gargling was also greatly reduced. Lack of appetite was the most persistent symptom, but by continuous efforts on the part of the dietitian he gained 12 pounds (5.4 Kg.) in six weeks. It was surprising to have him improve so rapidly, because I thought at the time that he had a compulsion neurosis, and it is not the rule for such patients to respond so readily to treatment. He was not hypnotizable, and showed little inclination to accept suggestions from myself or any other member of the staff.

His dreams were dramatic, visual objectifications of the conflicts that I have outlined. These conflicts were the conventional themes in any individual

development, namely: (1) A desire for distinction and self-determination, which was blocked by the father's dominating attitude and by the two humiliating "lickings" he received in 1924 and 1926 respectively. (2) A strong attachment to the mother, and as it appeared in his dreams, to the next younger sister. (3) The overt manifestations of sexuality in the form of masturbation; a strong sense of guilt in regard to it and the subsequent cessation of sexual development. (4) The detached, intractable and stubborn egocentricity.

Progress was such that in seven weeks he left the hospital and found residence in a nursing home.

Among other subjects about which he showed a decidedly resentful attitude was that of the mother's frequent pregnancies. Both the mother and he considered the growing size of the family to be the cause of the family difficulties and both united in blaming the father. In view of this state of sentiment, and knowing that the mother was about to be delivered of her seventh pregnancy, I hazarded the guess to the nurse at the convalescent home that his condition might take a turn for the worse when the child was born. After Christmas I was informed that the boy had suddenly become much worse, that all the symptoms — vomiting, gargling and water drinking — had returned, and that he had lost all the weight which he had so laboriously acquired in the previous two months. These symptoms commenced a few hours after he had heard that the mother had given birth to another daughter. He was much crushed and depressed. He said that he had something to tell me which he considered to be at the root of his troubles. He had promised himself that he would never tell any one, but he felt now that it was necessary. He then proceeded to describe vividly a culminating sexual assault on his sister, four year's his junior, which occurred in June, 1924. After the event, which was of an impulsive, explosive nature, he was utterly frightened and ashamed. The mother came on the scene and told him that he had committed the worst crime in Christendom, and finally led him away to an unfamiliar, distant church for confession. The priest repeated the mother's judgment. It was after this, he said, that he commenced the excessive drinking of water. Immediately after my visit, he fell asleep and dreamed the following: He was in a strange room. In the middle of the room was a cabinet. Two doors (as on a Victrola) opened, and out paraded seven small children, all of equal height. He stopped the last one, who was a girl. He put his arms around her and was about to ask her a question when he awoke.

A few days after our talk, all his symptoms had disappeared; he was once more on a reasonable diet and what seemed to be the road to recovery. Owing to the inaccessibility of the nursing home, he was not seen for three months, but I received good reports of him.

When I saw him in May, however, I was much disturbed by his condition. He had had no abnormal thirst, the mouth had not felt dry and the initial symptoms had disappeared with the exception of the anorexia; but now his mind seemed to be affected. He had had little to interest him in the nursing home, and a peculiar neutrality and unresponsiveness had developed. Memory had failed completely, and he had become completely unsuggestible and immune to his environment. He had gained a little weight but was extremely weak, and in consequence had fallen three times in the street. He had dragged one foot and complained of pain in the feet. He complained also of the following symptoms: dimness before the eyes, occasional headache, nosebleeds, noise of wind in the left ear, running nose and constipation. The most outstanding characteristic, however, was the regression of the mind. Responsiveness, attention, memory and feeling of reality seemed to be going fast.

Was this organic or psychotic? Or were these symptoms part of the general obsessional psychasthenic picture? It was found that he had been spoiled and undisciplined at the nursing home and that the diet had been neglected. With the help of the nurse, I interested him in activity — drawing, reading and playing games — and ten days later found a new home for him in the country.

Two weeks later, June, 1927, when I visited him a great transformation had taken place. He was sunburned, had gained in weight and looked like a different boy. He said that all symptoms had ceased. He was eating "like a horse" and drank only three glasses of water a day. He did not have headaches. He had achieved a new interest in living, and it seemed that his troubles were at an end. This, however, was not to last. He soon came to disagreements with two other boys living in the home and complained of maltreatment at their hands. He also refused to obey orders, climbed out of the window at night and visited places where he had been forbidden to go. In consequence, he was viewed by the householders as a problem of delinquent behavior rather than one of ill health. He seemed to be unmanageable. Finally, they refused to board him any longer and he was sent home. On July 11, he was taken to see Dr. Herman, who reported that he seemed to be doing fairly well. I saw him once two weeks later. He had continued to gain weight. The problem seemed to have resolved itself to a matter of adjustment to home conditions.

To summarize the state of affairs in July; this boy, I thought, had suffered throughout his life from indigestion. With him, as with the mother, early morning vomiting was not an infrequent occurrence. In his mind, moreover, it so happened that water had a particular meaning for him. He had been taught that a glass of water would drive away fear. It was a veritable case of conditioning. These were the two points of symptomatologic importance in the setting of affairs when, in June, 1924, the boy encountered a series of unusually disturbing events. Among the circumstances of psychologic importance should be included the fact that during the previous winter he had been led into the practice of small thefts, until in June, the crucial month, he stole a bicycle from the lawn of a house in the residential district. He considered this the worst thing he had ever done. He hid it in the cellar, but it was discovered by the family, and he was severely reprimanded. Then there were school examinations to pass and a new job to find. At this moment of stress one morning the father, when about to strike his wife, fell foaming at the mouth in a convulsion, which frightened the son who witnessed it. This was followed by the boy's initial onanistic experiences, defeat at the hands of a young rival, and finally the act of incest against his sister. For an idealistic, religious boy, such a succession of emotional insults seem to be sufficient excuse for any catastrophe from insanity to suicide. It seemed to me at the time that the "meaning" of water to the boy had been solved as one of two things or as a combination of them: (1) an antidote for fear, which was in accord with a life-long habit implanted by his mother's teaching, and (2) a symbolic act of redemption. As he said: "To clean out my urine." For instance, he said that he liked to drink from tall thin glasses and had bought some special ones for himself. He liked to think, he said, that he was drinking clear fresh water.

There were many other details which supported this hypothetical description of the psychologic genesis and history of the case. On the whole, it seemed that the story was as self-consistent as one could expect. Its practical relevance to the situation was shown to be nonexistent, however when, returning from a vacation, I saw the boy for the first time in six weeks and discovered internal strabismus and bitemporal hemianopia. Two days later, he was admitted to the Peter Bent Brigham Hospital.

Pathologic Report.—The patient was brought by Dr. H. A. Murray to the outdoor department of the Peter Bent Brigham Hospital on Sept. 15, 1927, complaining of headache and failing vision, and was admitted to the surgical service. He stated at this time that he had been having headaches for two weeks, that vomiting had persisted and that the fluid intake had diminished to such an extent that he only required three or four glasses of water a day. The mother said that the boy had complained for a month or so of blurred vision, but she thought that it had been diminished for the past five months. During the last month it had decreased so rapidly that on admission to the hospital he was unable to recognize people standing directly before him. For

three or four months he had complained of headache, but during the last month it had been so severe that he often cried out in his sleep, being suddenly awakened by the intense pain. During the last month he had vomited several times daily. He had been extremely sleepy, and often dropped off into profound lethargy from which it was difficult to arouse him. These attacks would, however, pass off quickly. He had such an attack after admission to the hospital, when Dr. Harvey Cushing was called to the ward as the boy was thought to be in extremis. When Dr. Cushing arrived he was sitting up in bed, alert and talking to his neighbors. The mother said that preceding such attacks of sleepiness he was often vague, disoriented and complained that he did not know where he was. The attacks occurred five or six times a day according to the mother, usually lasting from fifteen to twenty minutes. There had been double vision for the preceding two weeks; he had also gained considerable weight since the last admission.

On this admission the boy was definitely less emaciated. The skin was fine in texture, rather dry, and he had lost bodily hair. He gave the impression of an adiposogenital syndrome. He had been completely impotent for many months. There was thought to be a cracked-pot sound on percussion of the skull, but this was not definite. Examination of the ocular fundi gave rise to various opinions. The disk margins were fairly sharp, the disks themselves being a yellowish white, but no cupping was seen on either side. The retinal veins were full and in the left eye tortuous. The nasal margins of the disks appeared to be slightly elevated on the left side, while in the right fundus the central vessels appeared to protrude into the vitreous humor as much as 3 or 4 diopters. The pupils were large, and there was paralysis of the left external rectus muscle. To rough test there was a bitemporal hemianopia. He could scarcely count fingers with either eye. The temperature was subnormal, ranging from 96.5 to 98 F. The weight was 102 pounds (46.3 Kg.).

During the first night after admission, he shouted and screamed on several occasions and would constantly get out of bed to walk up and down the ward. He had attacks of drowsiness during the following day, when he could scarcely be aroused. He was rather vague and disoriented, but the condition for the most part did not seem in any way alarming. At 5:30 a. m. on September 19, he was found dead in bed.

Necropsy.—A complete postmortem examination was performed four and three-quarters hours after death. The internal organs were grossly normal with the exception of the suprarenal glands, which seemed smaller and their thickness less than usual.

When the head was opened, however, after injection of the brain with 10 per cent formaldehyde, 40 per cent solution, the convolutions of the brain were seen to be flattened, and on the base the leptomeninges were much thickened. There was a nodule of tumor surrounding the stalk of the hypophysis measuring about 1.5 cm., in diameter.

The optic nerves were completely involved in this neoplastic mass, and it was thought at first that the tumor was a glioma of the optic chiasm. However, when a median sagittal section of the brain was made this surface extension was found to be only a part of a huge tumor mass filling the third ventricle, invading the under surface of the corpus callosum and extending into both lateral ventricles, where it was spread in the form of flattened nodular masses over the walls of the ventricles. There were also nodules of the tumor in the floor of the fourth ventricle, but the aqueduct of sylvius was open. The region of the pineal body was occupied by a hard calcified nodule about 4 or 5 mm. in diameter, which seemed to be continuous with the tumor mass. The stalk of the hypophysis was greatly thickened, but the hypophysis itself was of normal size although somewhat flattened and shaped like a cup. Sections of the grayish tumor mass in the region of the pineal body and from the tuber cinereum showed the typical structure of a pinealoma, consisting of masses of large cells with spherical nuclei containing heavy nucleoli and little chromatin. The masses of large epithelioid cells were separated by strands of reticulin,

in the meshes of which were large numbers of small lymphoid cells. This association of the epithelioid and lymphoid cells is characteristic of pinealomas. In certain areas, there were differentiated large numbers of neuroglia cells, typical astrocytes with well differentiated neuroglia fibrils. The nodules in the walls of the lateral ventricles consisted almost exclusively of the large epithelioid cells. Sections of the hypophysis showed that the posterior lobe had been invaded by the tumor, which had almost completely replaced it. The anterior lobe was, however, normal. There were a few small cysts between the anterior and posterior lobes containing in their walls completely differentiated eosinophilic cells. The other internal organs (thyroid, thymus, suprarenals, parathyroids, liver, kidneys, pancreas, etc.) were normal. The testes, unfortunately, were not removed at necropsy.

DISCUSSION

Dr. William Herman: It seems to me that there is too much of the feeling that because a tumor was found in the third ventricle at autopsy the patient should not have undergone psychologic care. As far as I know, tumors in the third ventricle do not affect personality in the way that this boy was affected. After repeated neurologic examinations, no signs of a definite organic pathologic condition was found, and the patient was turned over to Dr. Murray for study. An extremely difficult family situation was discovered, as well as striking anomalies of personality in the boy. Definite remission of symptoms followed conferences with the physician when a good contact had been made. Recurrences of symptoms appeared when difficulties in the home situation arose. During the course of a long period of treatment, the boy did not show further evidences of organic changes until about six weeks before death. As soon as these were discovered by Dr. Murray, he sent the patient to a neurosurgeon. It is too much to expect that all persons who have pathologic intracranial conditions should have personalities above reproach.

This is an important case, because this boy, who possessed a definitely psychopathic personality, was thoroughly examined from the standpoint of organic disease. He was intelligently and sympathetically handled from the standpoint of personal maladjustments and was surrendered at the earliest possible moment when the intracranial situation warranted it. One type of treatment should not rule out the other. Both have their place, and this boy had both in their right places.

Dr. Gilbert Horrax: I remember this boy slightly, though I cannot recall him in sufficient detail to discuss the organic end of the case, but I believe, with Dr. Herman, that Dr. Murray should be congratulated on this psychologic study; it seems to me that the help he gave may have been a real help, though the boy did suffer from an organic disease.

Twelve pineal tumors have been verified at the Peter Bent Brigham Hospital. Four patients had diabetes insipidus. Two of them had pituitary tumors, as well as pineal, but the other two had simple tumors of the pineal body so that one knows that such tumors may cause diabetes insipidus, even though they do not grow forward into the third ventricle. Why this boy did not show any of the other neurologic evidences of pineal tumor I do not know, because even though they do grow forward, they generally give neurologic signs.

Dr. James B. Ayer: The spinal fluid in the case of this boy is of considerable interest. The case does not, apparently, fall into either the group of aseptic meningitis, such as is seen particularly in cases of otitis in which there is a considerable cell count, nor does it fall into the group of meningismus, in which there appears to be an excess of fluid without cells. This boy had repeated cell counts of moderate degree. Dr. Bailey stresses the large mononuclear cells seen in the fluid. It may be that some of those cells were tumor cells, but one sees large mononuclear cells frequently in cases in which there is no tumor. It is possible that a careful cell study made with the use of vital stains in the warm box would have determined the nature of these

cells. I am inclined to think that such a study should be made in doubtful cases, and I have on numerous occasions gone on record as stating that cell study in the spinal fluid is at present underrated, presumably owing to the fact that other tests have come in and have usurped the place formerly occupied by cell counting and cell study. I agree with Dr. Herman and others that Dr. Murray does not need to apologize for his psychologic study and the conclusions reached; they seem to me in no wise incompatible with the presence of a tumor. It is possible that the psychologic studies influenced the boy in his illness.

Dr. William Healy: I see no reason for Dr. Murray's half apologetic attitude toward finding psychogenetic symptoms present and psychotherapy useful in a case of organic brain disease. One of the most marked cases of a combination of organic disease with psychogenetic troubles that I have seen was that of a boy who presented extremely difficult behavior problems following encephalitis. He was found impossible in the schoolroom on account of erratic behavior. He exhibited a typical compulsion of hand washing. He performed certain rituals before he went to sleep; his eccentric habits included some oral behavior of a curious sort. When he came to the clinic he had developed a habit of falling to the floor so that he was constantly guarded in his waking moments and even at night by solicitous parents. This had gone on for weeks and months. Utilizing psychotherapy for a short period completely cured the falling trick. The determinants of his oral behavior were perhaps made clear by confessions to a nurse. Prior to this time, he had insisted that his knowledge of sex matters was nil. It appears in just such a case as this that the organic disease releases inhibitions — takes the lid off repressed and perhaps subconscious impulses, so to speak. Speaking humorously for a moment, some of us may remember Dr. Jelliffe's ideas about multiple sclerosis and other organic diseases, conceiving that they may be localized according to psychic influences. In the case of Dr. Murray, perhaps such a conception would be held of the localization of the tumor. The boy starts out with a water complex; if he has a tendency to tumor formation, where then should the tumor develop but in the region of the pituitary or pineal glands?

Dr. Bailey: This patient is interesting from many points of view. He serves to call attention to the fact that because diabetes insipidus is not controlled by the administration of pituitary it is not necessarily of mental origin. This mistaken idea is widespread and arises from the belief that diabetes insipidus is due to a lesion of the posterior lobe of the hypophysis and that administration of pituitary is a specific substitution therapy for the secretion of the posterior lobe. This may be true, but is certainly far from proved. We are far from an adequate understanding of the mechanism of diabetes insipidus. Not the least of the apparent paradoxes of this interesting malady is the fact that the polyuria often disappears with the progress of the destructive causative lesion, both in clinical cases and in animal experimentation. This fact is difficult to reconcile with the theory of a secretory product normally regulating the water metabolism of the body, for from this point of view the intensity of the polyuria should increase with increasing destruction of the secretory organ. Moreover, the facts are equally difficult to reconcile with the hypothesis of an irritative lesion. The whole matter is at present an inextricable tangle. One thing is clear, nevertheless; there exist cases of diabetes insipidus not controlled by pituitary which have definite underlying organic basis.

Another clinical syndrome imperfectly understood is pubertas praecox. It is often associated with tumor of the pineal body. In the present instance, there is no means of knowing at what age the tumor developed. This patient developed secondary sexual characters at the age of 13. That the tumor did not give other localizing signs (paralysis of convergent movements of the eyes upward, etc.) was doubtless due to growth into the third ventricle so that the commissures in the region of the corpora quadrigemina were not involved. The onset

of the diabetes was doubtless caused by a fragment of the tumor, broken off and implanted in the tuber cinereum.

This brings me to another point, namely, the presence of neoplastic cells in the spinal fluid. The nodules disseminated over the ventricular walls were doubtless due to implantation of cells floating freely in the ventricles. The large mononuclear cell reported in one examination of the lumbar fluid may also have been a tumor cell. Christiansen has pointed out that tumors in the region of the optic chiasm are particularly liable to cause dissemination of neoplastic cells in the spinal fluid. Better methods of examining the cellular contents of spinal fluid are sorely needed.

The main interest in this patient, however, is for the theory of the neurosis. One need not quibble as to whether there was a typical compulsion neurosis. Any clinical syndrome varies with the causative factors, and no one would maintain that in every case of compulsion neurosis there was a causative tumor of the third ventricle. That there may be in every case a lesion of some kind in the basal regions of the brain, is a hypothesis not so easily discarded. The importance of these regions of the brain for the emotional life is every day being clarified by clinical and experimental investigation. However, such an hypothesis is a mere hypothesis at present, with little evidence to support it. It is too bad, nevertheless, that careful necropsies are not more often done on neurotic patients. If the present instance means anything, they should often be very illuminating. I remember also a patient with major hysteria, somnambulism, etc., whom I saw in 1919 and occasionally after that time. No evidence of organic lesion was discovered at numerous examinations. She recently died of hemorrhage from a small hemangioma of the pons. The trouble with most psychologic studies is that a few chapters of the whole story are told. They are like novels without endings.

One does not know exactly what happened in the brain of this boy in June, 1924; possibly the implantation of a broken off fragment of tumor in the tuber, but it is evident that the insult to the brain initiated both the diabetes insipidus and the abnormal behavior. Predisposing factors already existed in the former case in the mechanism for water regulation and in the latter in his environment and mental attitudes (mother fixation, hatred of the father, inferiority complex, incestuous longing for the sister), but in both instances the abnormal reactions were precipitated by a definite insult to the brain.

It is here it seems to me that the inadequacy of freudian psychology becomes most evident and the broader view point of Janet more useful. Freud admits an organic basis for the neurosis and is only hesitant when it comes to the psychoneuroses (hysteria, obsessions and compulsions). His psychology is based on the study of the psychoneuroses, as he insists again and again and when he deals with them his writings appeal to one as containing a great deal of truth. The reality of the edipus complex must be evident to any intellectually honest man. It is almost too universal even to be considered pathologic. The same is true of the masculine protest, etc. When, however, Freud tries to extend the results of his study of a part to cover the whole of the neurosis, his writings impress one as very inadequate and at times as arrant nonsense.

Freud himself is conscious of the inadequacy of his conceptions. Time and again in his "Introduction to Psychoanalysis" he returns to the need for an economic point of view toward the development of neurotic reactions in such passages as the following: "We take this view in all seriousness; it points the way to an *economic* view of psychic occurrences. For the expression 'traumatic' has no other than an economic meaning, and the disturbance permanently attacks the management of available energy." "The motivating force of human society is fundamentally economic." "One can conceive the predispositions of all men to be qualitatively the same and to be differentiated only by these quantitative conditions." "A dynamic conception alone of these psychic processes is not enough, there is need of an economic viewpoint."

This economic point of view has been developed at length by Janet in his discussions of psychic energy and tension, and the story of this boy with its simultaneous oscillations of the clinical and mental disturbances is an excellent illustration of the value of his point of view. The polydipsia and polyuria in this case were not caused by a sense of sin, nor the vomiting by disgust. Neither were the compulsions caused by the diabetes insipidus, but the precipitating conditional factor underlying both the disturbance of external behavior and of the water regulation was an insult to the nervous system by a tumor. One might express it philosophically by saying that in one case the psychologic tension was lowered and in the other case the physiologic tension was lowered.

The essential lesson of this case, it seems to me, is to teach us as physicians, while not neglecting the situation, to keep our eyes open in every behavior disturbance for the other conditioning factor — an organic defect of the nervous system or a defect of the bodily economy on which its functioning depends. It is the best possible illustration of the necessity for these patients to be treated only by licensed physicians.

DR. MURRAY: In view of what seems to be an unusual correspondence between the psychologic and physiologic aspects of this case, it is well to attempt to "squeeze as much juice" out of the matter as possible; and to do this it seems advisable to present a brief for the psychogenic hypothesis in much the same spirit as an attorney presents the best possible array of evidence in defense of a client against state prosecution. Before I do so, however, I wish to affirm my belief that in the present state of knowledge the hypothesis that a psychogenic factor, such as a feeling of shame and ignominy, could contribute to the initiation of a pineal tumor is too speculative to be seriously defended, and therefore I must assume that the pineal tumor was the initial cause, and that the psychologic manifestations were secondary and complementary.

I am ready to consider as probable, moreover, the notion that the pineal tumor had some connection with the patient's moderately precocious genital development and conduct, and that an offspring of this tumor, lodged in the region of the tuber, became, perhaps, the chief causative factor in the bodily dehydration and polyuria; and further that the polydipsia and the incessant gargling of the mouth with water was consequent to the dehydration.

It is difficult for me, however, to explain the fact that pituitary, which is specific in some cases, did not help the polydipsia, whereas the father's stay in the reformatory did help it. Nor is it easy to see why after one week's psychotherapy the polydipsia ceased entirely until death ten months later, except for one remission immediately following the news of the birth of a sister. And is it not a strange accident of fate that the mother should have held and taught the children to practice the superstition that a glass of water was an antidote for fear? Does the tumor of the brain explain the persistent anorexia which accompanied the early attacks of indigestion during infancy, a state which he shared with the mother? Anorexia and vomiting, in fact, were the predominant symptoms. They commenced with the water drinking, but did not take on an acute form until the "licking" at the hands of the policeman in July, 1926. Psychotherapy never completely rid the boy of an early morning anorexia and an eccentric taste in foods.

It is interesting to note further that the spring of 1924 was a period of hypersexual activity; large genitalia, frequent erections, onanism and incest. After this functional apex, all activity ceased; no erections, no masturbation and no nocturnal emissions. It seemed at the time that the maturing sex instinct had been suddenly curbed by the humiliating impulsive act of incest and hence had deprived him of normal genital development.

In view of the not uncommon overt oral eroticism among boys of this age, and of his own knowledge of this practice from the hearsay of other boys, it seems not far fetched to imagine that the sex instinct should seek gratification by this route. If this wish were barred from consciousness, the symptoms would as usual tend to take the form of compensatory redemption rituals such as they

do in the common hand washing compulsions. On this basis the disagreeable dry taste in the mouth, the frequent mouth washing, the angioneurotic edema around the mouth and finally even the anorexia and vomiting, as indicating disgust, might be made consistent with the rest of the story. There is nothing extravagant in all this. One knows that a highly developed sexual disposition was suddenly deprived of further genital outlet by an act which gave him the maximum amount of psychic discomfort and shame. Regression to the oral route is the logical step, and the development of symptoms to assist in its repression, such as water drinking and mouth gargling, is exactly what any one who had had any acquaintance with persons with obsessions would be led to expect. The symptoms then would be seen as repressive manifestations against an overdeveloped sexuality appearing at the oral level. This theory is suggestively reinforced in a peculiar dream he had in the winter, of 1927. He dreamed that he held a long snake in his hand and walked up to his sister with it. Then he noticed that the snake had no eyes and no mouth. He held the snake up to his sister's face and its head invaginated itself over her chin and mouth until she was about to choke to death. He awoke in fright. He had the feeling that this was a significant dream, but he could make nothing out of it.

It is rare in any psychologic history to find greater self-consistency than exists in this case. It is also rare to find a case in which the patient responds so readily to treatment; for one must remember that in June, 1927, seven months after psychotherapy was instituted, and after about twenty-five interviews, the boy was in the country playing around without any of the symptoms of which he had complained since 1924. It is not certain, therefore, that the presence of the tumor did not simply force into existence a psychologic conflict which might otherwise have remained dormant, just as Lord Byron's club foot, which caused him such distress, might have been the initial basis for his Ishmaelism and, in consequence, for his love for his sister.

There is no question, in my mind, of an incompatibility between mind and brain theories. As a psychopathologist, I should be happy to discover changes in the molecular or histologic structure of brain plasm in the psychoneuroses. I am ready to indulge in speculations which image electronic or molecular vibrations in the cerebral cortex even while such an amateur as myself engages in these same speculations. The scientific and pragmatic questions are: 1. What objectively demonstrable physiologic and anatomic modifications correspond to the subjective and behavioristic phenomena? 2. To what extent may the physiologic and anatomic phenomena be controlled by purely psychologic means?

It is a fact of experience that a mere word may cause a subject to "blush to the roots," dilating the surface capillaries of the face; and in much the same fashion perhaps some epileptic seizures may be induced by a somewhat similar change in the capillary bed covering the cerebral cortex. The congestion brings about significant modifications in the physicochemical balance of the blood and tissues, and these modifications may be largely concerned in initiating the convulsive attacks. Would it be possible, for instance, in an early case of epilepsy to stop the periodic convulsions before organic changes had progressed to an appreciable degree? If so, would the organic changes disappear or persist? Such questions are of concern both to the psychologist and to the neurologist. The psychoneurologist would like to know what physiologic changes accompany specific affects or emotions or combinations of them; and what temporary or permanent organic changes occur as the result of the frequently repeated physiologic changes. Such a rapprochement of pathology, physiology and psychology can scarcely fail to be of mutual benefit to all parties. The psychopathologist should be the first to welcome the discovery that there is a lesion of some kind in the basal regions of the brain in every case of compulsion neurosis, and, moreover, he would be most particularly interested in knowing what, if anything, happened to the lesion after the compulsion was permanently cured by purely psychologic means. There need be no ill-feeling or controversy on such points as these between the investigators

who are primarily interested in the brain and those who occupy themselves mostly with the phenomena of the mind. They are not antagonistic, but complementary to each other.

I should add that I cannot entirely agree with Dr. Bailey's comments on the respective merits of the points of view of Janet and Freud. The organic bias of Janet, I would suspect, is largely due to the fact that he has not himself witnessed or effected many cures in severe cases of obsessions and compulsions. Freud, on the other hand, probably overstresses the purely psychic aspect of nervous disorders. As regards such figures of speech as "psychic tension," my personal opinion is that they are essentially meaningless and unreferential. Many people are deluded into thinking that psychology is becoming scientific when it borrows words and notions from the now antiquated physics of the nineteenth century.

NEW YORK NEUROLOGICAL SOCIETY

Regular Meeting, Dec. 6, 1927

GEORGE H. KIRBY, M.D., *President, in the Chair*

EXPERIENCE IN THE TREATMENT OF MULTIPLE SCLEROSIS. DR. MICHAEL OSNATO.

Dr. Osnato reviewed the work which began with Bullock, in 1913, on the bacteriologic etiology of multiple sclerosis, adding his experience in one case. While the evidence is on the whole equivocal and perhaps inconclusive, he stated that the transmission of multiple sclerosis to an ape by Steiner, in 1917, so completely fulfilled Koch's requisites that it had more value than many negative results. Based on the somewhat equivocal evidence that multiple sclerosis is due to a spirochetosis, silver arsphenamine has been used in the treatment of patients with this condition. Dr. Osnato showed two patients in whom remarkable remissions were obtained, one with a duration of twenty-seven months after gradual improvement during two and a half years of treatment, and another of one year after six months of treatment. The latter patient regarded herself as cured and never returned for further treatment until it was insisted on recently after a follow-up reexamination had been requested. Dr. Osnato recounted four other experiences of a favorable nature and stressed two points: almost complete rest for the first months of the treatment, and administration of 0.3 Gm. silver arsphenamine intravenously, weekly, in series of ten, with rest periods of one month. This treatment should be continued for two years, and Dr. Osnato repeated that favorable results were obtained precisely in those patients in whom it had been possible to continue the treatment for long periods. Most patients become discouraged, and this can be said also of the physicians. This is probably the reason why so many modes of treatment for multiple sclerosis have been advanced in recent years; they range from malarial inoculations to all sorts of nonspecific protein therapy, including vaccine therapy.

DISCUSSION

DR. BERNARD SACHS: I hesitate to open the discussion on this subject. I think that Dr. Osnato is fortunate in the condition of the patients presented this evening, whether the original diagnosis was correct or not. I have repeatedly reviewed the whole question of multiple sclerosis and must confess that the chief difficulty in deciding the question is the close resemblance between simple cerebrospinal syphilis and multiple sclerosis. That is a difficulty that is not easy to overcome. I should always hesitate to diagnose as multiple sclerosis the condition in a case in which the pupils have failed to react, and in which the symptoms are asymmetric, an important point, no matter what the other symptoms might be, especially if there was any doubt as to whether the condition might not be due to cerebrospinal syphilis. I stress that point of

the symmetry of symptoms and the symmetrical development of symptoms, because if there is one striking feature in genuine disseminated sclerosis, it is that the symptoms are, as a rule, distinctly and perfectly symmetric, perhaps not at first, but after the disease has lasted for a number of months; in simple cerebrospinal syphilis on the other hand, the symptoms are apt to develop in an asymmetric fashion. Spastic paraplegia as the only and chief factor in the diagnosis of multiple sclerosis is also rather a dangerous symptom. It is for that reason, after going over the literature carefully, that I was suspicious of Steiner's experiments. I was doubtful whether he really proved his case clinically. I question especially whether the existence of a spastic paraplegia in experimental animals, which developed some months after an initial injection, is evidence of multiple sclerosis.

I agree with Dr. Osnato on one point. A number of private patients, of all ages, have persuaded me of this, that as there is such a close relationship between cerebrospinal syphilis and multiple sclerosis, it is wise that every patient with disseminated sclerosis should be given most thorough antisyphilitic treatment. At the present time, specific treatment, and possibly even the malarial treatment, may prove to be the one line of therapy that will prove to be successful. Multiple sclerosis is such a protean disease and one which is now diagnosed on the basis of such scant symptoms that one must be careful in making broad generalizations.

If I were to see the second patient, I would not suspect that she had disseminated sclerosis, at least not at the present time; if the symptoms were much more pronounced a year ago, of course, that would be a rather important fact to remember. The trouble there again is that distinct remissions occur in multiple sclerosis, so that the question of differential diagnosis is extremely difficult. I have been much more inclined of late to think of the connection between encephalitis and disseminated sclerosis. Within the last few years I have seen a number of patients who have developed the typical symptoms of disseminated sclerosis after encephalitis, not a paralysis agitans syndrome, but symptoms so definitely resembling disseminated sclerosis that if I did not know the presumable etiologic factor, I would make the latter diagnosis. If there was one thing of which one was certain twenty-five or thirty years ago, it was that syphilis had nothing to do with disseminated sclerosis, but whether the case has been proved or not is difficult to decide. I do not think that the contribution is important, but Dr. Osnato will pardon me if I suggest that he will have to record additional cures before reaching a definite conclusion.

Dr. Joshua H. Leiner: In 1921, the work of Kuhn and Steiner was investigated in Marburg's laboratory. At that time the Jahnel method appeared for staining spirochetes in sections. Multiple sclerosis plaques from a number of brains were investigated. Careful examination for weeks failed to reveal spirochetes in recent or old patches. I thought at one time I found them, but my results were not confirmed by Marburg's studies.

In the Allgemeine Hospital Neurological Service, Wagner-Jauregg used protein therapy, particularly typhoid vaccine of the Besredka strain, which often gave excellent results. For the past few years I have used typhoid vaccine for shock reaction, which gave repeated remissions lasting from eight months to a year.

Dr. Osnato: I stressed carefully the equivocal nature of the claims made that multiple sclerosis is due to a spirochete in reading the review of the work that has been done. The only point I wish to make about the two patients that I have just shown is that the remissions in their cases differ from the ordinary remissions of multiple sclerosis in this important feature: the neurologic signs have not changed — there has not been any startling shifting of the neurologic status.

Dr. Sachs: Did you not say that these patients at the beginning had immobile pupils?

Dr. Osnato: No. The man showed diminution in response to tests of accommodation for near vision, and the reason for that is evident; he has a

paralysis of convergence and is therefore unable to accommodate well for close work. The pupillary light reflexes are normal and have always been so. I think it is important that the neurologic status has changed only in degree, which is entirely different from the ordinary remissions of multiple sclerosis. Every one knows that one can make an examination of a patient with multiple sclerosis today, can describe and record the status accurately and in detail, and three or four weeks later a reexamination may show that there has been a complete change in the reflexes and other phenomena. That has not been true in these two patients and some others with long remissions. The change is simply one of degree. The patients have improved markedly in their ability to get about and do things, but the neurologic symptoms remain practically the same. Loss in muscle strength and ataxic manifestations are favorably influenced, but the absent abdominal reflex phenomena remain practically the same. This, it seems to me, means an arrest rather than a remission.

Traumatic Partial Hemisection of the Spinal Cord: Two Cases Showing Motor and Sensory Changes. Dr. George A. Blakeslee.

Incomplete unilateral injuries of the spinal cord in the cervical region, with the resulting sensory and motor manifestations are uncommon and most often are the result of indirect violence — fracture or dislocation of the vertebrae.

Stab wounds of the cord are rare and give the most circumscribed and discrete lesions and hence the most limited and definite sensory dissociation together with localized motor manifestations. The symptom-complex of partial hemisection differs from the Brown-Séquard syndrome of complete hemisection in that in the former the contralateral sensory loss is limited to pain and temperature sensibility and disturbance in sensation in the dorsal column is not evident. Hyperpathic sensation (heightened feeling tone), so well described by Foerster, in which there is loss of the sense of pain and temperature on the side of the body opposite to the lesion was clearly demonstrated in these cases.

The cases I am reporting are those of two adults who were in good health until they received stab wounds in the left cervical region involving the spinal cord at about the level of the second and third cervical segments. In each case, there was a sudden flaccid hemiplegia on the side of the lesions with loss of pain and temperature sensibility on the opposite side. The flaccid paralysis soon became spastic, and in the course of a few weeks, there was almost complete recovery of muscle strength in the paralyzed limbs. Reflex change and abnormal associated movements still remain as evidences of paralysis of the upper motor neurons.

On the side opposite to the lesion, in each case, there was a loss of pain and temperature sensation from the second cervical dermatome downward. There were no other sensory changes except in one case in which the second, third and fourth cervical dermatomes on the side of the lesion revealed an impairment of tacticle, pain and temperature sensibility, with later some atrophy of the muscles about the left shoulder girdle. Hyperpathic sensibility revealed exaggerated feeling tone, in both cases, on the right side where there was a loss of pain and temperature sensation. This was usually referred toward the termination of the nerves.

The sensory changes showed beginning recession. In case 1, there was beginning return of pain and temperature sensation to the fourth cervical dermatome. In case 2, there was beginning return of the sensation of pain and temperature to the first thoracic dermatome. In one case, there was retention of urine for several days, while in the other incontinence of urine occurred for a few days. Both patients now have normal voluntary urinary control. At the present time, they are performing their usual duties.

It is thought that in both cases there was a partial hemisection of the left side of the cervical cord. The sites of the lesions were known with accuracy, and their nature limited the lesions to definite areas. The limitations were

shown by the results of examinations made several months after the injuries were received. With the clinical signs of paralysis of the upper motor neurons on the side of the lesion and loss of pain and temperature sensation from the second cervical dermatrome downward on the side opposite the lesion, it is thought that the wounds were discretely limited to the pyramidal and lateral spinothalamic pathways on the left side of the cord. At any level in the cord, the secondary neurons conducting impulses of pain and temperature from the lower levels have already crossed from the opposite side. The pyramidal tracts have crossed above and continue downward on the same side of the cord.

It is thought that the functional loss in these cases was not due entirely to structural damage. It is certain that neither the cells nor the fibers of the spinal cord regenerated, and hence improvement cannot be ascribed to such regeneration. Edema and other circulatory disturbances, however, exist in the vicinity of a traumatic lesion and may be the basis of many of the early symptoms which showed considerable improvement later.

Shock, defined by Sherrington as the whole of that depression and suppression of nervous function which ensues forthwith on a mechanical injury of some part of the nervous system and is of temporary nature, may explain the cause of the temporary flaccid type of left hemiplegia in each of these cases.

The pyramidal tract is situated more mesially than the lateral spinothalamic pathway, and therefore was probably less severely damaged than the latter in a lesion which obviously involved the edge of the cord and this may, in part, account for the rather rapid recovery of function of the pyramidal tract.

Head states that when there is an exaggerated affect or feeling tone on the side in which the loss of pain and temperature sensation occurs, it is essential that tactile sense be intact. In these cases tactile sense was preserved on the side in which a loss in the sensation of pain and temperature occurred, and in which the aggravated affect of feeling tone was extreme; here, tactile sensibility must have subserved the function of the transmission of sensations of discomfort as it did in Head's cases.

DISCUSSION

DR. MICHAEL OSNATO: These two cases might well be experiments, they so well confirm the work of Head. Dr. Blakeslee has given these cases a great deal of consideration and has described them meticulously.

COINCIDENT TUMOR OF THE BRAIN IN TWINS. DR. J. L. JOUGHIN.

This report is based on the histories of supposedly identical female twins, each of whom presented symptoms of an expanding intracranial neoplasm; the patients showed these symptoms synchronously. Cases of tumor of the brain of familial distribution are rare. A few cases have been reported in which brothers, or sisters, or brother and sister, have been so afflicted, but in all such cases the tumors have developed at different ages; such tumors have never been reported in twins, identical or nonidentical.

These two cases of cerebral tumor are therefore unique for two reasons: as occurring in twins and as existing in both patients at the same time. Besold, in 1896, reported the cases of two sisters, aged 11 and 16. Böhmig, in 1918, reported tumor of the brain in a brother, aged 23 and a sister, aged 38. Hoffman, in 1919, reported the cases of two brothers, aged 33 and 48. In the three reports the tumors existing in these siblings — for each family group — affected the same portion of the same organ, and were histologically of similar type.

There is nothing in the family history of my patients, as far back as it can be traced (three generations), that genetically interests us with the exception that the maternal aunt gave birth to male twins who died at an advanced age, one of diabetes, the other of pneumonia. The twins whose histories I am presenting I assume to be identical, as they were of the same sex, had eyes and hair of the same color, were of the same weight until adult life, and were of the same general mental and emotional make-up.

CASE 1.—The second born twin, Lena S., a Jewess, married, aged 32, was the first to come under observation. She was first seen in the dispensary on Oct. 26, 1918. She entered the hospital on Nov. 4, 1918. At that time she complained of: (1) occipital headache for six months, progressively growing worse; (2) weakness of the left extremities for three months; (3) numbness of the left hand and foot and an annoying "drawing sensation" through the left side of the trunk, for three months; (4) transitory intermittent diplopia on looking to the right for two months; and (5) diminution of vision for two or three months.

Neurologic Examination.—At that time the following deviations from the normal were revealed: (1) Voluntary Motor System: In the Romberg position, she swayed to the left and in walking favored the left leg. All nonequilibratory coordination tests were definitely poorly performed on the left. On the left all tendon reflexes were increased, and all cutaneous reflexes decreased. There was no ankle clonus or Babinski sign. A left hemiparesis of moderate degree was easily demonstrated, with slight hypertonia of the left leg. (2) Sensory System: Left hemihypesthesia and hemihypalgesia, affecting all modalities of superficial sensibility, was present. Muscle, joint and tendon sense was deficient on the left, especially in the feet. Stereognostic sense was deficient in the left hand. (3) Cranial Nerves: The symptoms were normal, except for a left facial weakness of peripheral origin, the relic of a former Bell's palsy, and the following conditions of the eye: (*a*) anisocoria, the left pupil the larger; (*b*) papilledema of 4 diopters in each eye; (*c*) complete left homonymous hemianopia. All laboratory observations, including those in the cerebrospinal fluid, were normal.

Course.—The patient left the hospital on Nov. 20, 1918, and was seen at intervals in the dispensary, but finally disappeared from observation, to be seen again in July, 1919, on the service of Dr. Bernard Sachs at the Mount Sinai Hospital. The clinical and laboratory observations there were practically identical with mine. Both hospital groups independently arrived at the diagnosis of intracerebral neoplasm, probably a glioma. On July 12, 1919, Dr. Elsberg performed a right craniotomy. The brain was under great pressure. A mass could not be detected by palpation of the cortex. The ventricles were aspirated, and 75 cc. of yellowish fluid, with abundant cholesterol crystals, was withdrawn. The observations were indicative of a tumor near the ventricle with evidence of an old hemorrhage into the ventricle. The patient failed to rally and died twelve hours after the operation.

Necropsy Observations.—At autopsy, a large fungating tumor mass was seen on the base of the brain, probably originating from the right hippocampal gyrus, compressing and distorting the optic chiasm. This mass extended upward into the third ventricle, occluded the right foramen of Monro and produced a marked dilatation of the right lateral ventricle with resultant thinning of the cortex. The tumor tissue proper — firm, translucent and grayish white — was relatively small in amount, but showed plainly that repeated abundant recent and old hemorrhages had taken place within it. The walls of the right lateral ventricle and the fourth ventricle were covered by a thick, partly organized membrane evidently the result of old hemorrhagic effusions. The histologic diagnosis was glioma.

CASE 2.—The first born twin, Sarah M., also married, preceded her sister into the world by an interval of five minutes. She was referred to me in January, 1920. The history of the illness is not so clear-cut as that of the sister, and in some respects is contradictory. I will summarize, emphasizing the main points.

The patient came to me complaining of "spells" of seven years' duration. These "spells" consisted of a tingling feeling in the right foot; this aura mounted to the hip, and the leg became weak with a tendency to give at the knee, so that she had to stand still until strength returned to the member. Occasionally she fell if the leg gave way. During the two and a half years

previous to January, 1920, there was added to the symptomatology of the "spell" spasmodic flexion of the leg at the hip and knee joints, which shortly subsided, and the foot which had been jerked off the floor could again be placed on it. On the whole, these "spells," at first confined to the right leg, but later also involving the left, became worse. They occurred especially when she was frightened or upset, and had been more pronounced since the death of the sister six months previously. At the time of the first neurologic examination, which did not reveal anything abnormal, she had no other complaint than the "spells." She was regarded as probably neurotic, and appropriate treatment was instituted with results that were not entirely unsatisfactory.

The next complaint was of occipital headache, which occurred first on Feb. 10, 1920, the day after a fall in which she bruised the shoulder but did not strike the head. After a few days, this passed away. In March, 1920, she entered the hospital for further study, and was discharged three weeks later, no new data of value having been elicited. By June or July, the headaches were occurring more frequently, were more severe and of longer duration. Neurologic examination at this time still gave negative results. The eyegrounds were normal, and as late as September 21, nine months after she was first seen, a note was made by Dr. Ward Holden "sensibility, mobility, pupils, fields, and fundi normal." During October she began to complain of tinnitus, or rather a noise, deep seated, in the center of the head. The headaches grew worse.

Examination.—On or about November 22, the patient, who had not been seen since October 11, was found by me to have a beginning choked disk, the existence of which was confirmed by Dr. Holden. Neurologic examination for the first time revealed definite diagnostic data: slight right facial weakness (?); slight weakness of the right arm and right leg; tendon reflexes increased on the right, but no adventitious reflexes; right abdominal reflexes possibly diminished. There were no other physical signs. A diagnosis was made of cerebral tumor—probably in the left hemisphere, but not further localizable. It was thought, however, that owing to the alternating symptomatology, sometimes the left leg being the weaker, sometimes the right, the tumor must be near the central line, or at least be large enough to exert direct pressure across the central line.

Course.—At the request of relatives she was referred to Dr. Walter E. Dandy, of Johns Hopkins Hospital, who, on Dec. 19, 1920, performed a left craniotomy, partially removing a huge subcortical tumor from the left hemisphere. The tumor mass extended into the left ventricle and beneath the falx into the right hemisphere. The patient rallied well and went home. She returned to Baltimore six months later, and on June 19, 1921, succumbed from shock shortly after a second surgical operation. The histologic diagnosis was glioma.

A Study of a Maladjusted Family. Dr. Sarah R. Kelman.

This study concerns an orthodox Jewish family, both parents and five children. The parents, though totally without education, are hard working, honest and self-respecting and are possessed of high ideals. They were both born in a European country and came to the United States when young. The father is the youngest of five children; his own father was a kindly but weak person; the mother was the boss in the home. The mother is the fifth of seven children. Her father deserted them when she was young, and all the children were cared for by the maternal grandparents. She began working at an early age and at 13 came to the United States, where she supported not only herself, but also her mother and the two younger children. She developed into an efficient, self-reliant and self-sufficient young woman. She did not make any friends. She married at the age of 21, because "one must marry some time." While she respected her husband, she never loved him. He was in love with her, however, and never crossed her in anything she wished to

do; their relations consequently remained harmonious. She never adjusted herself, however, to her duties of mother and homemaker. In fact, there was no home; she spent most of her time in the husband's store and let the children manage the housekeeping and themselves as best they might. After the birth of the second child, the mother developed a severe neurosis which incapacitated her for about two years. She has had frequent hysterical episodes since. Being possessed of much native intelligence, she realized that she should not have more children. Those that followed came in spite of repeated abortions. When she did not definitely neglect them, she overindulged and coddled the children.

The eldest child, Mary, was 17 in June, 1927. She was sickly up to the age of 6 and was proud of it. She was an average pupil in school, having an intelligence quotient of 108, and was a model in deportment until the age of 8. An incident, insignificant in itself, occurred in school in the handling of which the teacher showed poor judgment. From then on she behaved poorly at school. At home no change was noted until toward the end of the first year at high school. She began by being inattentive in her classes, spent a great deal of time in the lavatory, and frequently looked wild eyed and dazed. At home she showed some deterioration, became careless about her appearance, self absorbed and slow. She began staying out late at night, refusing to give any account of herself. In May, 1925, she stayed away from home for four days. When found and examined, she was eight months pregnant. She then confessed to promiscuous sex relations for some time. She was brought to the Post Graduate Hospital Psychiatric Clinic. Her general attitude and behavior suggested a diagnosis of dementia praecox of a simple type. For a time she showed definite improvement, but on July 25, 1927, she disappeared from home and has not been back since.

Robert, aged 16, was always delicate, ate poorly and was a bed wetter until the age of 12. He was rather effeminate, but possessed an ungovernable temper. He never had friends of his own age. He was always disobedient at home. In school, he was bright and quick to learn; his intelligence quotient was 118. He was fond of reading, especially Sabatini and Poe. He was always courteous to teachers, but never was liked by his schoolmates and did not make friends with any of them. His first real difficulty came at about 11, when in the company of some older boys he stole some supplies from the school. Much was made of it by the school authorities, and through it he received his introduction to the juvenile court. He entered high school at the age of 12, more than four years before this presentation. In spite of a bright mind, he has not completed a full term's work in a single subject in all this time. He has disappeared from home twice, the second time in July, 1927 (before the sister). He was picked up by an officer, to whom he told a fancy story about his father being a drunkard who beat him and his brother most unmercifully when intoxicated. He is now in a protectory.

The third child was 13 in March, 1927. He had several attacks of pneumonia and bronchitis. He wet his bed until he was 10. At present he is well behaved, both at home and in school. He is serious-minded and has only one friend at a time. At home he is the mother's mainstay. Recently, however, the mother became panicky because he brought home some low marks on his report card. She always reacted in a neurotic way toward the children's schooling.

Hanna, the fourth, was a healthy child until the age of 8, when she was nearly run over by a trolley car. Fear of punishment for playing out on the street made her keep the incident from the mother. The next day she began to shake so violently that she could scarcely eat. She has shown choreiform movements ever since. The condition became so acute that she was finally brought for treatment. She was found to be suffering from true chorea, but with a marked psychogenic element. She is affectionate and serious-minded, and is precocious both at home and in school. She has no playmates. Recently she has been indulging in much day dreaming and fantasy. The mother is alarmed, perhaps not without cause.

The baby, nearly 8, still wets the bed at night and at times wets herself during the day. She is frail and eats poorly. The mother still feeds her. She is precocious, likes school, plays the piano unusually well for her age and likes to show off. She usually plays alone.

With the exception of the father, the entire family seemed to "enjoy" ill health. The difficulty had its inception with the grandparents, through an interplay of environmental forces and intrapsychic conflicts. The father, who was apparently well adjusted, was none the less handicapped by his own father identification and mother fixation. He married and tacitly allowed his wife to usurp his place as head of the family. He completely failed his children. The mother, strongly schizoid, failed to adjust herself to married life. She resented her household duties and children and finally found escape in a neurosis. Thus the children were actually deprived of both father and mother. Because of a subconscious feeling of guilt, she overcompensated by making much of minor ailments and coddling the children. Of this the children took full advantage, as it was the only way they could secure any attention. There was thus created an atmosphere of chronic invalidism. This in turn made the children self-centered and seclusive.

Although the foundation was well laid in the home, one feels that the school must take some of the blame. It is inconceivable how a child could be allowed to remain four years in the same class in a modern high school without some effort being made to find out the difficulty, especially in the case of a child of superior intelligence. Therapy, to do any good, must include both parents, especially the mother. The prognosis must be guarded, but much depends on the management of the situation from now on.

DISCUSSION

DR. PHILIP R. LEHRMAN: The presentation of this material is instructive and interesting. It shows that when a patient comes to a psychiatric clinic, not only he, but also the setting in which he moves must be evaluated, and at once it develops that the familial and sociologic factors as well as the intrapsychic evidence of interplay between these various forces are involved. As Dr. Joughin, in the preceding paper, traced the embryologic fate of the indidual cell, so here we have heard the psychologic fate of persons in a family with maladjusted ancestors. The father, the youngest son of seven children, was a passive person because of a passive father and an aggressive mother. He married a woman like his mother who became the dominant personality in the home, and thenceforth it became a woman's world. The mother made a bad job of it—in trying to be both parents she became neither, and the children's "ideal-ego" became poorly developed; the subsequent maladjustments are correlated with, if not the result of, this mixed up state of affairs.

SECTION OF NEUROLOGY AND PSYCHIATRY OF THE NEW YORK ACADEMY OF MEDICINE

Dec. 13, 1927

WALTER M. KRAUS, M.D., *in the Chair*

VEGETATIVE INSTABILITY AND ITS RESPONSE TO TREATMENT. DR. GEORGE H. HYSLOP.

In 1924, a man, aged 23, whose past history was of no consequence, was troubled with eructations and frequent bowel movements. These symptoms were relieved by diet and modifications in hygiene. In 1925, he had nervous attacks in which he noticed shortness of breath and a constriction in the throat. He was given tincture of belladonna for this and shortly afterward had an attack of palpitation with rapid pulse; after that, he worried about his heart.

He next found that he began to feel fatigued when he stood for a long time. He grew gradually unable to stand any physical exertion and had sudden attacks of vertigo; his heart constantly beat rapidly. On physical exertion, palpitation and acceleration of the pulse were much greater. He did not lose weight and slept well. He usually felt well in the morning but by the end of the day was exhausted. Sexual desire decreased in frequency. He enjoyed his work, had normal interests and recreation, and did not show abnormality in his sexual life. He was under treatment by various physicians without receiving benefit. However, the administration of iodine had decreased the pulse rate. In June, 1927, a basal metabolic rate of plus 65 was found. Absolute rest was enjoined.

The patient came to me about July 1, 1927. Physical examination showed hypotrichosis and visceroptosis with a ptosed heart. The skin was moist; the musculature had poor tone, and the skin stroking test showed a markedly prolonged red line. Signs of hyperthyroidism or tremor or eye signs were not present. The pulse and blood pressure response to position and exercise were of interest and indicated poor vasomotor tone. The pulse rate at rest was 96; when the patient stood, it was 130. The blood pressure at rest was 134 systolic; 76 diastolic, and when he stood, it was 114 systolic; 80 diastolic. Hopping raised the pulse rate to 150 without elevating the blood pressure.

Ephedrine, ¾ grain (48 mg.), three times a day, a high fat diet, cod liver oil and passive exercises with abdominal massage were prescribed. The ephedrine slowed the pulse but caused a peculiar feeling in the chest and a pounding in the heart. The dose was reduced to ⅜ grain (24 mg.). By August 1, the patient felt an increase in energy and was troubled with neither palpitation or unduly rapid pulse. However, examination as yet did not show any objective change.

By September 1, the digestive symptoms had disappeared, the patient was not troubled at all with circulatory disturbances, and he had become able to perform moderately strenuous exercises without ill effects. He had gained 4 pounds (1.8 Kg.) and observed that this was his first improvement in more than two years. The pulse and blood pressure responses now showed improvement. The pulse rate was 96 when the patient was recumbent and was 120 when he was standing. When he was recumbent the blood pressure was 120 systolic; 80 diastolic, and when he was standing it was 112 systolic; 80 diastolic.

On November 16, the patient did not present any complaints except that at the end of a hard day he would feel slightly tired. There was an additional increase of 6 pounds (2.7 Kg.) in weight. The heart was no longer ptosed. The muscles and vasomotor status of the skin were normal. The pulse and blood pressure responses were normal. The basal metabolic rate was reported as plus 20.

Comment.—This patient is presented because of the unusually high basal metabolic rate not due to thyroid disease, and also because of the effects of ephedrine on the pulse rate. The clinical picture might perhaps be termed neurocirculatory asthenia. This type of patient is often difficult to classify because of the frequency with which the physical complaints reflect the emotional cause; often these patients are regarded by neuropsychiatrists as being psychoneurotic. This patient's anxiety about his heart was natural. In this instance a determinable psychogenic basis for the symptoms was not found, and the concern over the palpitation was alleviated somewhat by reassurance, but it was alleviated chiefly because the treatment instituted was successful in combating the symptoms. I do not wish to assert that the treatment prescribed here is the only successful treatment possible.

DISCUSSION

DR. PARDEE: I was interested in this patient particularly from the standpoint of etiology. The cause for such disturbances frequently is an acute infection and I will ask Dr. Hyslop whether there was any history of cold, influenza or

possibly encephalitis which might have precipitated vegetative imbalance such as this patient showed. From the standpoint of the patient's constitutional habitus, I think that he is of the thymic suprarenal type, a type which is prone to have sympathetic instability and which will have symptoms that simulate some of the glandular symptoms, such as those of the thyroid or suprarenal, and yet appear to be not true to their usual form. Whether this man had an increased thyroid secretion or not it is hard to say, but I should be inclined to think that the thyroid was definitely involved in spite of the fact that he did not have exophthalmos or other symptoms associated with hyperthyroidism.

Will Dr. Hyslop give his opinion as to why the patient got better. I am interested to know which of the therapeutic agents that he gave he thought was of most benefit to the patient.

Dr. Hyslop: This patient did not have an acute infection preceding his first symptoms. They came on shortly after he moved to a suburb and had to commute every day to New York. I think that, with his make-up, the extra load tipped the balance.

As to the thyroid disease, I doubt if he had it because the regimen adopted was contrary to what one would dare use for a man who had primary thyroid disturbance. He began to improve when he exercised and was given massage, and when he was told to stop "lying around."

Dr. Pardee asked what made him better. What was more or less a shotgun prescription was given first to increase his weight: a high fat diet, vitamins in cod liver oil, and ephedrine, because of its specific effect on vasomotor tone: finally, passive and later active, exercise was prescribed as a direct tonic for vasomotor tone. I think the one most important factor in this case was the vasomotor instability.

Focal Epilepsy Due to Chronic Sphenoid Sinusitis. Dr. George H. Hyslop.

A woman, aged 31, had been troubled with progressive deafness in the right ear for about five years. Routine measures were unsuccessful in combating it. She was not subject to infections of the nose and throat. On April 15, 1927, while talking on the telephone, she became suddenly unable to say the words that she wished to speak. At the same time she noticed numbness and tingling in the right hand. For about twenty-four hours she was unable to speak at all but could understand what was said to her. At the end of forty-eight hours, the speech had improved. She came to me on April 11. A "cold" in the head appeared and was accompanied by headache which was localized in the temple and over the vertex. Occasional blurring of vision also occurred.

Physical examination revealed a slight hesitancy in speech, with anomia, a diminution of the right wink reflex and a questionable right plantar response. The ocular fundi, visual fields and acuity of vision were normal. The patient did not have fever.

In the next few days nasal discharge and sneezing appeared, and the headache and the defect in speech improved. A slight but definite facial weakness was present by April 23. Examination of the sinuses by Dr. Hirst on this date revealed surprisingly badly diseased sphenoid cells. Exenteration of the sphenoid and ethmoid cells was done the next day.

The necrosis of the sphenoid cells indicated that they were diseased. Local symptoms stopped soon after this operation, and the slight signs of focal disturbance of the brain have not returned.

My colleagues and I at Bellevue Hospital have seen a few patients with symptoms indicating involvement of the temporal lobe that are due to chronic sphenoidal disease. The diagnosis in these patients is osteomyelitis of the sphenoid cells and extension of inflammation, with the meningeal reaction over the tip and undersurface of the left temporal lobe. The patient was fortunate in not having developed either an abscess of the brain or a diffuse infective meningitis. The absence of retrobulbar neuritis and uncinate phenomena is perhaps worthy

of comment. The localization in the temporal lobe is based on the type of aphasia, the sensory aura in the right hand, and limitation of motor weakness to the facial muscles.

AN ANALYSIS OF THREE HUNDRED AND THIRTY-ONE CASES OF INJURY TO THE HEAD IN CHILDREN WITH ESPECIAL REFERENCE TO END-RESULTS. DR. FENWICK BEEKMAN.

From an analysis of 331 cases of injury to the head in children with a follow-up report of 234 cases, the following conclusions were drawn: As a rule children stand severe injuries better than adults, as their resistance to damage to the body and their reparative powers are better. This is due to the fact that their bodies are young and that they do not have other pathologic lesions to act as handicaps. This is apparently true of injuries to the head as well as other injuries. The fact that the dura is not strongly attached to the bones of the vault and that the vessels of the dura lie in comparatively shallow grooves in the inner surface of the skull prevent laceration of the dura and brain in fractures of the vault. This also accounts for the rareness of extradural hemorrhages and allows diffuse separation of the dura from the bones in hemorrhage in the extradural space, the blood often escaping from this space through a fracture line and forming a hematoma under the scalp and thereby relieving the brain from compression.

Fractures of the vault may be frequently overlooked, as in many cases there are few if any symptoms, though hematomas of the scalp frequently overlie the fracture line. The extent of a fracture line of the vault is not of any prognostic value in the severity of the cerebral injury.

A simple depressed fracture of the skull is not in itself an indication for operative intervention. Compound depressed fractures are more serious than simple depressed fractures, not only because of the danger of infection that may follow but because they more frequently produce lacerations of the dura and brain. When operation is performed for compound depressed fracture, fragments of bone should be replaced, if possible, so as not to leave a deficiency in the skull.

Fractures of the base of the skull in children may be overlooked because of the lack of clinical symptoms. Injury to the brain is more commonly found accompanying fracture of the base than fracture of the vault. This is especially true of fractures of the middle fossa.

Symptoms resulting from injury to the brain clear up rapidly after the first forty-eight hours in persons who recover; in those who die, death usually takes place in the first two days.

Symptoms of meningeal irritation without actual meningeal infection are often observed. Meningitis follows fractures of the anterior fossa more frequently than of any other part of the skull.

About 23 per cent of children suffering from injuries of the head have some type of sequelae, but few of them last. Less than 5 per cent have symptoms due to permanent injuries. As a rule, it can be stated that sequelae are present in direct relation to the severity of the damage produced by the injury.

Patients with fractures of the vault show a lower morbidity than those with fractures of the base, especially of the middle fossa.

The symptoms complained of in the sequelae are more often of a subjective or emotional type than those of an objective type caused by a definite lesion. Headache is the commonest complaint. It was found as commonly in those with slight injury to the brain as in those with severe injury. It almost always clears up within a year after the accident. Emotional instability is observed frequently. This varies from marked nervousness to a total change from the child's former behavior. The latter symptoms are found more frequently in children who suffered from a more serious injury to the brain.

Conservative treatment appears to give the best results in injuries of the head in children. Operative procedures undertaken without definite indication are to be condemned.

DISCUSSION

DR. CARL G. BURDICK: Both neurologists and surgeons should feel indebted to Dr. Beekman for this large collection of case reports with fairly careful follow-up in a large proportion of them. I was agreeably surprised that the percentage of permanent sequelae was so low. My impression, as I had observed a good many of these patients in the wards and the follow-up clinic, was that it was much higher.

I want to emphasize a few points that Dr. Beekman has brought out. Conservatism is the keynote of the treatment of intercranial injuries in children. Most of the focal symptoms will disappear if the patient is left alone. Simple depressed fractures do not require operation. All compound fractures should be operated on and, if possible, the bony fragments replaced. In the patients I have observed in whom the fragments have not been replaced and in whom infection has followed, the infection is usually accompanied by a hernia of the brain which subsides as the infection subsides.

Patients with cranial defects who have been followed in the clinic afterward do not show any tendency toward spontaneous closure. If these patients are to be operated on for closure of a cranial defect, I think that they should be operated on only by a surgeon who has had particular training in neurologic work. I have made the mistake myself of operating on these patients, and I know that other surgeons have done the same; I feel that the physician who is equipped for neurologic surgery and not the general surgeon is the one who should attempt these closures.

DR. T. K. DAVIS: As one who has not the closest contact with the surgical side of this subject, I believe that I can speak better of certain aspects of trauma of the head in general; for instance, the sequelae of such trauma apart from fracture. One thinks first of the fact that in children the greatest danger perhaps is that the late result will be epilepsy and, in contrast, that in the adult, the immediate sequela which is most prominent and of most interest to the clinical neurologist is the question of traumatic neurosis. The mere fact that Dr. Beekman does find that certain children show the functional subjective symptoms that one associates with traumatic neurosis is, I believe, evidence of the importance of organic changes in the etiology of traumatic neurosis in contrast with the 100 per cent emphasis on psychogenic factors. He did point out that several of the children that he saw showed grave changes in behavior and subjective sensations of various categories. Those are the symptoms that come in traumatic neurosis. The fact that the child does not understand the psychology of compensation appears to have considerable importance here.

In his paper on traumatic neurosis, Dr. Osnato places emphasis on the organic factors and suggests a new term, traumatic encephalitis. There is a great deal of good sense in that because whether or not one stresses molecular changes or disturbances of perivascular connections, the condition does become something like an encephalitis, although perhaps I do not entirely agree with the term. I think it is better to adhere to the word concussion and let it mean more than it does at present.

DR. BYRON STOOKEY: Will Dr. Burdick forgive me if I greet him as a neurologic surgeon? He has shown remarkable restraint and conservatism which I think is the keynote, as Dr. Beekman has pointed out, in treating these patients. Certainly, traumatic injuries in children present a much more favorable aspect than they do in adults. I am extremely interested in the lack of permanent injury in these cases. In only 5 per cent were there any sequelae at all, and these seem to be minor. I am interested too in the fact pointed out by Dr. Beekman, that even injuries of the nerves cleared up. Of ten or twelve

patients with injuries of the cranial nerves, I believe that in only one did facial paralysis remain permanently. I am much interested to know how long the other paralyses remained and if possible what the nature of the fracture was, because one sees some of these patients in whom there is a question of whether peripheral nerve anastomoses are indicated in order to regain the function of the seventh nerve. I have never operated on such patients and am glad to say that I have not done so for fear that I might have operated on one who would have recovered spontaneously. It is wise to wait a longer time to operate than one ordinarily would in persons with injury to the cranial nerves of this origin.

It is also interesting that the seven patients who died of meningitis had fractures in the anterior fossa. I presume that the fracture line—Dr. Beekman did not say so—perhaps ran into the sinuses or into the cribriform plate. Of course that is the most frequent cause not only of infections and of diffuse infections but of abscesses and, though rarely, of suction of air into the brain. As a matter of fact, the first encephalogram produced by fracture of the skull, reported in New York, in 1912, showed air within the brain and the ventricle. The fracture ran not only through the frontal sinuses but had severed the brain substance and connected the ventricle with the sinus. The man was sucking air into his own ventricle, which produced a beautiful ventricular outline. It would be interesting if Dr. Beekman would state what treatment he gives these patients while they are recovering.

Dr. Sylvester Leahey: Will Dr. Beekman describe the follow-up of the eye signs as indicative of increased intracranial pressure and also tell whether this was checked by lumbar punctures showing the pressure of spinal fluid?

Dr. Stephenson: I think that fracture of the skull in children is probably a different proposition from that of an adult, as implied by Dr. Beekman's statement. One can produce a great deal of acute disturbance in a child without sequelae. It seems to me that the make-up of the child before the accident is of vital importance, as are the surroundings to which he is taken when he leaves the hospital, where he has been under ideal conditions. A patient was brought in recently who, three years before I saw her, had an injury of the head; it was said to have been a fracture but it was never verified by the roentgen-ray or by treatment in a hospital; yet the child had believed during the entire time that she had had a severe fracture of the head and had been prevented from going to school; finally, the Bureau of Attendance compelled the child to undergo examination at my clinic. There, a careful neurologic examination, including roentgenograms of the head, did not show evidence of fracture. Consequently, I would emphasize the personality make-up of the child prior to the injury, the conditions under which he is living, and whether the parents are unduly emphasizing, as many parents do, the importance of injury of the head and its permanence.

I have seen a number of constitutionally psychopathic persons with an injury of the head, that had not produced a fracture, who showed a great deal of personality deviation and complained of headaches, dizziness and all sorts of symptoms that apparently were referable to the injury; yet, knowing their make-up to be instable, one was reasonably sure that the condition was the result of this instability prior to the accident and not of the accident itself.

I do not know the particular kind of treatment Dr. Beekman uses with children, but I believe that neurologists have to do the best they can to prevent sequelae. I think that it is generally agreed at Bellevue Hospital that a long stay in bed, irrespective of the amount of objective or subjective trauma, is the most valuable aid in the prevention of the so-called traumatic neurosis. It is the policy there, from a neurologic point of view, to treat these patients accordingly. I think that rest, irrespective of the objective symptoms, is important; a stay of at least six weeks in bed is absolutely necessary to prevent traumatic sequelae.

In the adult, the triad of symptoms most commonly encountered is: headache, dizziness and general malaise.

Will Dr. Beekman answer this question: Are there frequent instances of sequelae in which there have been definite objective manifestation at the base of the skull—bleeding from the ear without any apparently roentgenographic manifestation? In other words, I believe that it is difficult to demonstrate a fracture of the petrous bone. I have a patient in mind who when first seen gave definite evidence of a fracture of the skull—bleeding from the ear and escape of spinal fluid—though repeated roentgen-ray examinations showed nothing abnormal. The question is what would the roentgenogram have shown if the skull had been studied at the time of the accident?

DR. KRAUS: Statistical summaries of cases occurring during the war and others have been extremely variable concerning the incidence of choked disk. I do not know whether Dr. Beekman's patients have been examined for this and should like to hear what he thinks about this aspect of the subject.

DR. BEEKMAN: It will never be known whether the residual symptoms are due to definite pathologic changes in the brain or not; those patients who show sequelae do not come to autopsy, while those who come to necropsy are usually examined before the symptoms have appeared. My belief, however, is that there is no such condition in children as a traumatic neurosis following a fracture of the skull. Recently, Penfield has shown by means of lumbar insufflation of air that he can cure a number of patients with frontal headaches, the result of fracture of the skull. He believes that there are adhesions between the membranes of the brain and that the air breaks up the adhesions.

In these children the headaches most frequently followed fracture lines in the vault. I believe that they followed only fractures of the vault, which produced cortical hemorrhages and adhesions.

The symptoms of emotional behavior appeared most frequently in children with fractures at the base; the symptoms were much like those observed in encephalitis—instability and complete emotional change of the child. I did check up the question of the family surroundings, the type of homes from which the children came and the child's character before the accident. This was done by social service workers and by interviews with the children's teachers. Undoubtedly the children with emotional make-up showed more change than those that were of an unstable type. Nevertheless, I believe that there was a definite change in the brain following the accident which later became corrected.

I am much interested in the fact that there were not many residual paralyses of the cranial nerves, as Dr. Stookey has brought out. Of those that did show such paralyses, all but two became cured during the time they were followed. This fact reminds me of some observations I made several years ago, on the sensation of a pedicle graft—when the skin was removed from the abdomen and placed on the arm of a child. In time these flaps developed sensory nerves, so that the child could feel the touch of cotton; while adults whom I have examined never developed fine sensation in skin transplanted by flaps.

Consequently, I think that a child will often regenerate sensory nerves or even motor nerves that have been divided. In nerve suture, children regain function much more rapidly and more completely than adults do. Therefore, I have no doubt that if a facial nerve is divided in a child there is a possibility that it will regenerate. Other examples of this are cases in which operation is performed on the glands of the neck; six months or a year later a facial paralysis that has resulted from the operation will clear up.

In all of the cases in which meningitis developed after fracture of the anterior fossa, the fractures involved the cribriform plate. In all there was either bleeding from the nose or the child vomited blood soon after the accident.

The treatment I have adopted has been of the simplest nature. When a child came in it was placed in bed with the head elevated. I have used the ice cap as they do in other hospitals. For the last four or five years I have been using hypertonic salt solution by rectum and lumbar punctures when indicated. I

do not use lumbar puncture indiscriminately. In cases that show signs of compression or marked irritability, lumbar puncture is ordered.

I agree with Dr. Stephenson that one of the most important things is to keep the children quiet and away from emotional strain. At Bellevue Hospital they are kept in the hospital for about three weeks and then sent home with instructions that they should be kept in bed for another two weeks. I believe, and I think that Dr. Burdick believes, that if possible one should keep these children longer. If kept in an environment in which they are not irritated by too much attention from the family and in which they can be kept quiet they stand a much better chance of not developing sequalae.

Unfortunately, complete examinations of the eyes have not been made in all these cases. Some time ago I tried to examine the disks as a routine but was disappointed, as I never found anything abnormal in them. I do not think that in children, except in exceptional cases, one finds marked choking in the disks. I believe that a child frequently decompresses itself under its scalp through the fracture line, because so many children show hematomas in fractures of the vault. Hematomas are seldom seen in fractures of the vault in adults. There are two reasons for this. The dura is more tightly attached to the inside of the skull and the scalp more firmly attached to its outside in adults, while in children, immediate pressure is relieved by the blood leaking through a fissure in the skull, as shown in the case that I have reported.

I believe that fractures which involve the base alone or the petrous portion of the temporal bone alone are seldom discovered by the roentgen-ray and that most fractures of the base are discovered by the roentgen ray when they extend, as they often do, into the vault. To be discovered by the roentgen ray, a fracture at the base alone would require multiple exposures made in many planes.

PATHOLOGIC CONDITIONS COMPLICATING FRACTURES OF THE SKULL. DR. B. M. VANCE.

The pathologic lesions caused by fractures of the skull were classified most conveniently according to the cause of death. They were subdivided into four categories:

1. Death due to cerebral concussion or its sequelae, such as exhaustion and terminal pneumonia.

2. Deaths due to cerebral compression caused by:

(a) Subdural hemorrhages, which in most instances were due to contrecoup lacerations of the brain and to a less extent to direct lacerations of the brain. Rarely, the hemorrhages resulted from the tearing of veins tributary to the superior longitudinal venous sinus, or from the tearing of old adhesions of the brain to the dura, or from laceration of the dura and the middle meningeal artery in such a way that the artery bled into the subdural space. In some cases the laceration of the brain caused cerebral compression without any measurable amount of subdural hemorrhage. At times the brain seemed to increase in volume after the fracture, and this phenomenon has been designated as edema of the brain.

(b) Epidural hemorrhages, which were due to laceration of some blood vessel on the outside of the dura by the sharp edges of the fracture. The middle meningeal artery was torn in most instances, while a few cases were recorded of laceration of the lateral venous sinus and the anterior meningeal artery with the formation of an epidural clot.

3. Deaths due to suppurative meningitis and other forms of intracranial sepsis. The most common form was suppurative leptomeningitis, with a few examples of suppurative pachymeningitis interna and externa, abscesses of the brain and septic thrombosis of the venous sinuses.

4. Deaths due to miscellaneous conditions. These included deaths from postoperative shock, a death from hemorrhage during a craniotomy because of a lacerated superior longitudinal sinus, and deaths from epileptiform convulsions

associated with old adhesions of the brain to the dura. A number of patients died as the result of injuries elsewhere in the body. In other cases death was due to a natural cause or to some other condition not associated with the fracture of the skull.

The fractures of the skull were classified so as to designate the anatomic form and location of the fracture, and to indicate in a general way the direction and the intensity of the force which caused the fracture. The subdivisions were:

1. Fractures of the vault and base: *(A)* anterior location (*a*) linear fractures and (*b*) composite fractures; *(B)* lateral location *(a)* linear fractures and *(b)* composite fractures; *(C)* posterior location (*a*) linear fractures and *(b)* composite fractures.

2. Fractures of the vault alone: *(a)* linear fractures; *(b)* composite fractures, and *(c)* depressed fractures.

Lantern slides illustrating different fractures of the skull and some of the intracranial complications which attend these injuries were shown.

DISCUSSION

Dr. Charles Norris: Architecturally speaking, the cranial cavity is most interesting and may be described as not resembling a tumbler; there are no contrecoup fractures of the skull, although that was the original French view. If one raps a glass sharply with the finger, on the opposite side there may occur a fracture or crack in the glass. This is not true of the skull because of its buttresses. There is the buttress that extends along the middle of the skull over the frontal, parietal and occipital bones; at the occipital protuberance, it is joined by the transverse buttress—the occipital bone with the ends leaning under the sphenoid. The temporal bone is beveled inside the parietal bone, so that it gives the skull some sort of elasticity when struck. The frontal buttresses impinge on the malar and sphenoid bones. When there is an impact, the force of the impact is distributed along these buttresses. Occasionally, a linear fracture crosses the posterior buttress through the occipital bone but usually the fracture runs either to the right or the left side of the posterior buttress.

Another point is that, like faces, not any two skulls are exactly alike either in shape or in thickness. One skull may be fairly thick in the frontal region; rachitic skulls may be much thicker in the posterior portions and extremely thin over the temporal lobes; in some skulls the squamous portion of the temporal bones is much thicker and is usually associated with thickening of the frontal bone or thickening of the occipital bone.

Dr. John A. McCreery: I wish to emphasize how much the staff at Bellevue Hospital owes to the medical examiners and to the close contact with their work. The observation of Dr. Vance's work has led the hospital staff to a much sharper and clearer classification of the cases which require definite surgical intervention. On the first division, at the present time, operations are performed only on patients with compound fractures, on those with epidural hemorrhage with recognizable local pressure and occasionally on patients showing generalized pressure without evidence of marked injury to the brain in whom nonoperative measures have failed to reduce the pressure.

Dr. Stephenson brought out the importance of rest in these cases, and my colleagues and I agree completely with what he has said. We attempt to keep the patients with fractures of the skull in bed in the hospital for from three to four weeks. This is difficult on an active service, and at times at the end of three weeks they are sent home with instructions to remain quiet for another three weeks before coming back to the follow-up clinic. The difficulties are to a certain extent modified by the fact that, at the end of a week or ten days many patients feel entirely well, and it is impossible to make them realize the importance of staying quiet longer. They get up and go about their business.

In the follow-up clinic, one sees distinct differences in the later course, depending on the length of time that the patients remain quiet. The patients who

go back to work at the end of a week or ten days almost invariably come back complaining of headache or of localized symptoms such as dizziness, occasional dimness of vision, and differences in taste and smell, and often with the complaint by the family that their dispositions have changed. Patients who have stayed quietly for from four to six weeks suffer from these complaints in a much smaller percentage of cases. In the seven years ending Jan. 1, 1927, approximately 475 patients with fracture of the skull have been studied, with a total mortality of about 35 per cent and an operative percentage of 12 per cent. I think that this percentage was distinctly lower in the last year or two than it was during the first years of that period, largely as a result of the increasing use of lumbar puncture and hypertonic solutions.

I should like to hear from Dr. LeWald on the question of roentgen-ray diagnosis. There has been a good deal in the literature lately on this subject. So far, at Bellevue Hospital, we have been unable to develop a technic on which we could depend in the roentgen-ray diagnosis of fracture of the base.

DR. E. D. FRIEDMAN: One of my professors in medicine, the late Dr. A. A. Smith, maintained that no one had the right to draw any conclusions from his observations unless he could marshal at least 500 cases on which to base diagnostic inference. Dr. Vance certainly has earned the right to the conclusion which he has drawn, and I am much indebted to him for the graphic and lucid way in which he has presented his subject. I had the privilege of reading his paper on "Fractures of the Skull." What he presented this evening is only a small part of the immense amount of work that he has done in this field. There is nothing to be added to his presentation of the immediate results of fractures of the skull. As neurologists, we are concerned somewhat with the sequelae of these fractures of the skull, some of which have been alluded to this evening.

While the old theory of Oppenheim, which postulates molecular changes in the brain as a result of concussion, still has some adherents, it has been modified by the more recent work of Foerster, Wartenberg, Schwab, Heidrich and others who have carried out encephalography in these cases. From their observations in patients who recovered from fracture of the skull, it is known that there are sequelae caused by anatomic changes in the brain and the meninges. These changes are denoted in the encephalogram by internal hydrocephalus, atrophy of the brain, accumulations of air on the surface and sometimes by isolated collections of air in the form of subarachnoid cysts. Of course, not every patient who recovers from fracture of the skull need be subjected to this procedure; but a certain number of them have demonstrated conclusively that the symptoms of which these patients complain are real, and have an organic basis. I have had occasion in two instances to demonstrate such changes in the brain.

The question of swelling of the brain is of great interest. I should like to offer an explanation for the swelling of the brain which occurs following fractures of the skull. In the first place, Ricker, the German observer, has done a good deal of work on vasomotor tone in the blood vessels of the brain; paralysis of vasomotor tone with local stasis and diapedesis occurs. One can also readily understand that when profound injury to the skull and its contents has occurred, the glial system (the "lymph path of the brain") is seriously interfered with; a certain amount of infiltration of the brain substance takes place, and the result is swelling.

It has been noted, too, that some of the patients who recover from fractures of the skull develop meningitic changes, some of which I have already alluded to. There may be a leptomeningitis with the formation of meningitis serosa circumscripta, similar to that observed in the spinal cord. Some of the post-traumatic epilepsies may be explained on this basis. It has also been observed that changes take place in the blood vessels themselves; there is thickening of the walls of the vessels with partial obliteration of their lumina, which may lead to lobar or insular sclerosis in the brain. The late sequelae of fractures of the skull, therefore, have an organic basis which modern neurologists must take into consideration.

I believe much as Dr. Davis does that the neurologist should not dismiss these persons with so-called traumatic neuroses with the dictum that they are malingerers who are trying to get from society what they have been unable to obtain by legitimate means. It is the business of the neurologist, however, with every means at his command, to eliminate organic disease in these persons.

I think that it was Wilson, an English worker in this field, who said that any man who has sustained a serious injury to the skull is never the same afterward. While the statistics obtained during the war have not entirely borne out that statement, yet the period of observation in many instances has not been sufficiently protracted to warrant a definite statement on that point.

When I was younger and more enthusiastic, I carried out vestibular tests in some of the patients with so-called traumatic neurosis. In many instances I was surprised to find that the first syringe-full of fluid injected into the patient's ear produced a violet reaction. The vertigo was severe, and profuse vomiting occurred; falling and past-pointing reactions were marked. The abnormal caloric responses seemed to me to indicate disturbances in the vestibular mechanism similar to those observed in the so-called irritable labyrinth. The latter is extremely sensitive to even slight changes in its circulation, and it may be that the increased irritability of the labyrinth in these persons is due to vascular changes occurring as a late sequel of the injury sustained.

In most instances, the symptoms complained of are so utterly uniform, without any apparent collusion between the patients, that I believe that, in justice to the patients, one ought to consider their complaints organic in origin.

Dr. LeWald: The roentgenologist is much interested in the effort to diagnose fractures of the skull and particularly fractures of the base. Dr. McCreery is right in his statement, and I think Dr. Beekman mentioned the fact, that it is exceedingly difficult at times to demonstrate a fracture of the base by means of the roentgen ray. However, a careful examination with about six stereoscopic exposures enables one to state with a fair degree of certainty whether or not a fracture has occurred. Dr. Dixon has a fractured skull at the New York Eye and Ear Hospital, that he has shown me, in which he has endeavored to demonstrate a small fracture in the base of the skull that is visible on the specimen, and yet one cannot see it on any roentgenogram. One will have to admit, therefore, that a fracture of the skull may exist at the base and not be demonstrable roentgenographically. On the other hand, every effort should be made to demonstrate a fracture, and the more care that is made to demonstrate a fracture of the base, the more often it is demonstrable.

I agree with Dr. Norris that not any two skulls are alike and that this fact is often brought to the front in medicolegal cases in which some supposed antecedent lesion in childhood has left a peculiarity in marking of the skull, particularly in the vertex. The variation he has spoken of is most important in cases of that sort, as on either side it is apt to be brought out that a particular variation is due to some previous trouble; yet it can be duplicated in a person who has not had a previous lesion or injury.

How long can a fracture line in the skull be demonstrated roentgenographically? How long does it take to obliterate the line? This question comes up frequently. A roentgen-ray examination may not be made for a considerable interval after the injury, and yet the symptoms have indicated that a fracture was present. Some authorities have made the statement that a line may be visible for as long as a year. In one of my patients, the line could be made out nearly three years later. I am hoping that possibly Dr. Beekman may be able to trace some of his cases roentgenographically and see how long the fracture line is visible.

Book Reviews

KEIMDRÜSE, SEXUALITÄT UND ZENTRALNERVENSYSTEM. By DR. OTTO KAUDERS. Price, 10.80 marks. Pp. 194. Berlin: S. Karger, 1928.

To discuss the gonads and their relation to the sexual life and the nervous system within the limits of a comparatively short monograph is a difficult task. When one considers the complexity of the problem, its intimate interrelation with many branches of biology and the mental sciences, the difficulty of definition of its limits, and the numerous and conflicting theories that have arisen in both the biologic and the psychologic appreciation of it, it is evident that a clear exposition of the problem is difficult, and yet that an impartial presentation is essential. The monograph under review does not pretend to be an exhaustive study of the subject. It is, however, a clear and concise, even if at some points somewhat too brief, presentation of the outstanding features.

The material is presented in the form of what the author calls ascending levels; it begins with a description of the glands, passes through the interrelation of these with the whole organism, their influence on the sexual life of the subject, their relation to the central nervous system in general, and finally the psychic component. Throughout, the data and points of view of different workers in the field are presented impartially, even if briefly, though at various points the author states definitely his own conception of the problems discussed. After a brief historical review, the question of the internal secretion of the male gonads is considered. The possible origin of this secretion from any one of the following elements is discussed: (1) germinal tissue proper (spermatogones, spermatocytes, spermatids, and spermatozoa); (2) the Sertoli cells; (3) the interstitial cells (Leydig), as has been suggested by different observers. The author comes to the conclusion that the most important rôle in the production of the internal secretion is played by the germ cells proper; the secretory function of the interstitial cells is of rather secondary importance and serves to safeguard trophic and regenerative conditions in relation with the germ cells proper. In a similar fashion the internal secretion of the female gonads is discussed. In the ovary, too, three tissue elements have been regarded as productive of the internal secretion by different authors: (1) the follicular apparatus (the follicular wall, the liquor folliculi and the ovum itself); (2) the corpus luteum (menstruationis et graviditatis) and (3) the so-called "interstitial gland" (Bouin). Following a presentation of the pros and cons of the different theories, the author expresses his agreement with the view of Fraenkel that the corpus luteum plays the most important rôle in the physiology of menstruation, nidation and development of the ovum. He is of the opinion that the lutein tissue should be regarded as the producer of the hormone which influences the different biologic phases of the generation of the female organism. The secretions which control the maturing processes, the appearance and preservation of the secondary sexual characteristics, however, are produced by the follicular tissues.

The second chapter deals with the experimental attempts to influence the sexual life by the internal secretion of these glands. The "rejuvenation" experiments of Steinach are discussed, and the author concludes that, following bilateral vasoligature in senile animals, changes occur in certain organs and functions, especially in the sexual behavior. The duration of this effect is rather short and depends essentially on the resorption of spermatogenic substances; it should be regarded as an organotherapeutic measure. The most striking effect is a temporary increase in sexual potency, but observations on animals do not seem sufficiently definite to permit the postulation of similar occurrences in men. The attempts at experimental sexual metamorphosis and experimental hemaphroditism are then presented. In most cases the success

of the experiment seems to depend on the type of experimental material. Only very young castrated animals seem to react to the experiment; animals that have passed the stage of puberty do not show an appreciable change. In the former, transplantation of gonadal tissues of the opposite sex seems to cause the appearance of secondary sex characteristics of that sex. It is questionable, however, how much the castration itself has to do with this. The experiments of Voronoff, which depend on an homoplastic transplantation of testicular tissue directly into the scrotum, have been reported as particularly successful. The author is of the opinion that here too only a temporary effect is produced.

The relation between gonadal function and the sexual instinct in man is discussed in the third chapter. The effect of disturbances in the functions of these glands on the sexual life of the person are considered. The effects of castration, even though striking in physical aspects, do not necessitate extinction of the sexual instinct. It seems to have different effects in the two sexes. In general, preclimacteric castration produces diminution in the sexual instinct, in most cases a substitution of its objects, and in a certain percentage a complete disappearance of sexual desire. The latter seems to be much more dependent on the gonadal glands in man than it is in woman, and hence the sexual behavior of the male reacts much more promptly and decisively to changes in the function of the gonads than it does in the female. Other disturbances of gonadal function, such as hypofunction and hyperfunction of the glands, also bear definite relation to the sexual life. For instance, in the so-called retarded puberty, which goes with hypogenitalism, a defect in the production of the sexual hormones, the sexual instinct and psychosexuality of the person are much reduced. Contrary to this, however, in precocious puberty there is an early development of the primary and some of the secondary sexual characteristics, but without a concomitant growth in psychosexual life. Here, however, it seems that the internal secretion of the gonads plays only a secondary rôle. The hormone production of the gonads is not the only factor that activates sexual behavior in the human being; in the adult especially, various other elements combine to shape the final form it assumes.

Experimental investigations of the biology of the sexual life have found application in clinical practice. One of the most important attempts in this direction was the vasoligature introduced by Sharp which was followed up by psychiatrists in different countries. A review of the data reported, as well as results with his own cases, leads the author to assume the following attitude: vasoligature in young persons may cause a change in sexual libido, but does not seem to decrease the sum total of its energy. Furthermore, this change, which does not seem to be permanent, is much influenced by the environment. Vasoligature, as originally practiced for purposes of influencing hypersexuality and sexual perversions, is thus seen to be of rather limited application. The second indication for vasoligature is in cases of senility, presenility and precocious senility. Vasoligature here is not always followed by effects on the sexual life. Half of the cases do not seem to react at all. The next important clinical application of experimental sexual biology is transplantation of the gonads. There are three conditions in which this transplantation has been suggested: (1) loss or atrophy of the gonads; (2) eunuchoidism; (3) homosexuality. The experiences reported in the first of these are hopeful. Transplantation in such cases seems to meet with varying degrees of success. In the second field, the transplantation is not so successful, especially if the operation is undertaken after the usual age of puberty has been reached. Observations of transplantations in cases of homosexuality are not as yet sufficiently definite to admit of either acceptance or rejection of this mode of treatment. Cases in which a certain, even if weak, heterosexual tendency exists seem to be successfully influenced by the operation. In this connection the author discusses the attempts of Voronoff to replace heterotransplantation by homotransplantation. His results, especially in presenility and precocious senility seem to have been successful. Attempts by others in this direction, however, have not been so successful.

Is there any definite basis for the assumption of a direct influence by the central nervous system on the gonadal function and sexual instinct? Research through experiments on animals points definitely to the existence of nerve centers, some of which stimulate and others inhibit the sexual reaction process. The supposition of Gall that such a center in man was localized in the cerebellum has been followed by clinical and experimental investigations. So far no isolated cerebral center for the control of sexual function has been found. As to the center of control of the internal secretion and the nutrition of the gonads there seems to be no doubt that it is situated in the base of the midbrain. All experiences with encephalitic material point also in that direction. These would justify the following general statement: the midbrain, especially the base (tuber cinereum, infundibular region and corpora mamillaria) is the controlling sphere of sexual function in general, not only of the regulation of internal secretion and nutrition of the glands but also of the sympathetic-parasympathetic control of the somatic sexual process. It must be remembered, however, that this center is not the only one in the nervous system, but that the whole representation of sexual control in the central nervous system must be looked on as a series of centers superimposed one on another, so that there are spinal as well as cerebral centers.

The last chapter deals with the psychic structure of the sexual instinct of man. The author discusses the various points of view of different schools, the phenemonologic approach of Scheler and Schneider; the Spranger and C. Bühler attitude; Kronfeld's conception; the psychoanalytic theory of Freud; and the individual psychology of Adler are all presented more or less briefly. The psychoanalytic theory is discussed more fully than the others, and although the author accepts some of the postulates and general trends of this school, he takes a somewhat critical attitude to others. He emphasizes the fact that so far no correlation between some of the concepts of this school (regression and the sexual life of the infant) and actual physiologic data has been established. He himself would rather take the attitude of Kretschmer who speaks of the sexual instinct as "not an independent psychophysical quantity, but an inextricably interwoven component of the whole personality." The sexual experience represents one instance of the psychophysical personality and should be regarded as a phenomenon representative of the psychic component of the personality as well as of the organic sexual structure.

An extensive bibliography completes this interesting and highly commendable monograph.

THE SOCIAL BASIS OF CONSCIOUSNESS. A STUDY IN ORGANIC PSYCHOLOGY BASED UPON A SYNTHETIC AND SOCIETAL CONCEPT OF THE NEUROSES. By TRIGANT BURROW, M.D., PH.D. Price, $4. Pp. 251. New York: Harcourt, Brace & Company, 1927. International Library of Psychology, Philosophy and Scientific Method.

In his volume on the "Social Basis of Consciousness," Dr. Burrow presents "a societal concept of the neuroses." It is not the author's intention to offer an elaboration of psychiatric or psycho-analytic theories; he suggests rather the need to adopt an altered basis in our attitude toward neurotic disorders. The individual disturbance is not considered in this thesis as an isolated, circumscribed phenomenon, but as the expression of a generic socialized pattern. What is presumably the mental disorder of the patient is not treated here as a localized, personal condition, but it is brought into relation to a disordered function existing in the social organism at large.

Not only is the patient a socially determined element, but the investigator, along with him—as Burrow points out—is intricately interwoven in the network of the human interchanges which he undertakes to observe. The observer in the psychiatric field has not yet realized how much his actions and thinking, and with this his scientific procedure, are biased by his own emotional involvement. The "objectivity" of his method, though taken for granted, becomes

problematic when he is dealing with moods and reactions in which he himself is participant. There is need for a larger and more inclusive attitude.

It is the distinction of Burrow's thesis that it is not developed on speculative or merely "mental" grounds. As the author indicates in the preface it was less his own preference than the force of circumstances which brought him into close contact with the position he presents. Compelled to make a thorough scrutiny of his own daily moods and actions, along with those of his social environment, he came to question seriously the biologic validity and vitality of our socially accepted habituations. With the further development of his studies into group investigations he had added opportunity to realize the extent to which the individual—in his customary as well as in his pathologic trends—is influenced by and is at the same time part of a socially continuous structure of moods and interactions. Thus, the individual and his symptom were consistently viewed on the background of the living social pattern of which he is an element.

In the normally accepted forms of interaction there are, as the author emphasizes, all the symptoms of repression, substitution, transference, dissociation and other factors which have been thought to be characteristic of the neurotic disturbance. It will be necessary, therefore, to view the disturbance of the individual together with and in its relation to a disintegrated emotional condition existing in the larger social organism. To focus the emphasis on the patient would mean to misplace the therapeutic interest. As long as the phyletic or generic significance of the individual's disorder is not fully realized in our methods, we adhere to a merely symptomatic and inadequate procedure.

The psychopathologist has not only to view his subject from a standpoint that comprehends the neurotic symptom as the expression of a generic pattern, but to realize that he is participant also—part of an emotional structure of which his patient presents only another aspect. Hence an inclusion of his own involvement, though it may contradict his habitual feelings and prepossessions, is a prerequisite for an accurate view and understanding of human pathology.

Unless the observer replaces his habitual private view by an inclusive and consensual attitude, he has no basis to judge adequately the influence which artificial and superficial images exert on the individual's outlook and interaction. As the author outlines, there is the need to approach from an "organic" position the mental fictions of a self-protecting and restricted ego such as has been impressed on the growing organism by the competitive, self-centered codes of his social surroundings. The parents, as natural representatives of the social system, have bent their child's mentality on his own image. Henceforth, the illusion of a self-defensive, separativistic "I" impedes all direct and outflowing action. An external "mental" motive, unstable and self-limited, has become the guiding principle and has taken the place of a more genuine, internal and racial orientation. The individual takes in consequence a moral stand opposite others and opposite himself; the continuity with his congeners and with his organic self has been interfered with.

A "normality" thus composed cannot constitute a safe criterion for biologic function and health. The "sexuality" of the normal, his "will to power" are hardly basic phenomena, for they are already influenced by the interposition of substitutive images. What has been accepted as true emotion or instinct contains already the elements of a self-mirroring compulsion and thus does not express the essential needs of the organism. The more sensitive person, the neurotic, cannot reconcile this contradiction, though in his revolt he embodies the same antibiologic trends as the environment about him.

The psychopathologist, thus, is confronted in his patient with a social problem, with a situation in which he himself is directly involved. He has to deal with phenomena which he cannot separate from his own experience. In viewing subjective processes the scientist cannot arbitrarily exclude his own subjectivity. And it is just the limitation of the merely intellectual, "mental"

outlook with all its covert self-contradictions and incongruities which is definitely brought to question in these pages. Even our accepted psychiatric procedures have not escaped the self-centered tendency within the social structure about us. There is a definite need for reconsideration and revision of the principles on which our methods are based.

BEITRÄGE ZUR KENNTNIS DER MONGOLOIDEN MISSBILDUNG (MONGOLISMUS) AUF GRUND KLINISCHER, STATISTISCHER UND ANATOMISCHER UNTERSUCHUNGEN. (DIE BEDEUTUNG DER GEBÄRMUTTERSCHLEIMHAUT UND DES AMNIONS FÜR DIE AETIOLOGIE UND PATHOGENESE DIESER MISSBILDUNG.) By DR. W. M. VAN DER SCHEER. Paper, price, 12 marks. Pp. 162 with 44 illustrations. Berlin: S. Karger, 1927.

This study is based on an investigation of 348 cases of mongolian idiocy, approximately 150 of the patients having been seen by the author; the data concerning the other cases were secured through communications with all physicians in Holland, the fact of mongolism being determined by the author from photographs and detailed descriptions of the patients. Reports concerning 185 other cases were discarded as insufficiently established, though many of them probably belonged in this category. The material is described in five main sections dealing with: (*1*) general considerations; (*2*) etiology; (*3*) somatic and psychic phenomena; (*4*) pathologic anatomy and (*5*) pathogenesis.

The principal conclusions reached are given by the author as: 1. Mongolism belongs to the morphologic series of malformations in which the picture is controlled by median skull defects. 2. All the anomalies can be explained as a result of deficient size of the amniotic sac, which produces its most harmful effects during the sixth and seventh weeks of fetal life. 3. The amniotic defect arises from faulty implantation of the ovum in an abnormal uterine mucosa. 4. The manifestations that become evident during later life—the metabolic disturbances, the trophic disturbances and in part probably also the psychic phenomena—can be explained by hypoplasia of the diencephalon with defective development of the centers of the vegetative, autonomic nervous system.

The material is well presented and the arguments are clearly documented. The literature has been studied exhaustively, and the various theories and observations are admirably reviewed; the bibliography is excellent. The statistical information contained in the text is of great value, being based on conditions in Holland which is compact and excellently organized for the care of mental defectives. The author had an unusual opportunity for work of this kind by reason of his official position as inspector of state care of mental disorders. The book can be recommended to all interested in the field of bodily malformations and mental deficiency.

TROUBLES NERVEUX ET MENTAUX DANS LES MALADIES TROPICALES. By A. AUSTREGESILO. Pp. 140. Rio de Janeiro and Sao Paulo: F. Alves, 1927.

This volume is based on lectures delivered by the author at the University of Paris and the Institut Franco-Brésilien de Haute Culture. It deals with some little known aspects of certain tropical diseases and chiefly with their influence on the nervous system.

The first chapter is devoted to brief descriptions of nervous disturbances in Chagas' Disease (a form of trypanosomiasis), malaria, beriberi, ankylostomiasis, nervous leprosy, ainhum and bubonic plague.

The second chapter deals with the psychoses of infectious origin, and more especially with those resulting from tropical diseases. The author concludes from his review of the subject that infections, as claimed by many authors, are causes of mental disturbances, and that those causing most of the tropical diseases are no exception to this rule. They show, in fact, the same clinical manifestations as the psychoses produced by other infections. Such acute febrile infections as yellow fever, bubonic plague, malaria and other conditions show types of febrile delirium, infectious delirium, postinfective psychic debility,

collapse delirium (rare) and amentia. Infections of chronic character, such as leprosy, may in rare cases be accompanied by mental disorders. Blood and intestinal worms produce dysphrenia. Trypanosomiasis produces psychic disturbances, but in Chagas' Disease there is not an infectious delirium, although it may exist during the acute stage of the disease. Cases of infantile encephalopathy associated with idiocy and imbecility are frequent. In beriberi, psychic disturbances are usually of the type described by Korsakoff; according to the author, latent and elementary psychic disturbances are frequent. Cerebral cysticercosis determines psychic modifications analogous to those generally caused by cerebral tumors, but their pathogeny is in this case of toxic origin.

EPIDEMIC ENCEPHALITIS (ENCEPHALOMYELITIS). By LEO M. CRAFTS. Price, $3. Pp. 223, with 15 illustrations and 5 charts. Boston: Richard G. Badger, 1927.

The author's attempt, as stated in the preface, has been to put in book form, all available knowledge concerning epidemic encephalitis. The subject has been fairly well covered in a reasonably logical manner. The book in reality is a compilation with eighty-one titles mentioned in the bibliography—and with case records, more or less complete, added from the author's practice. Such a book can be read with some advantage by the general practitioner and without much difficulty, as the author has followed his avowed purpose of adhering strictly to the simplest terms. There are too many errors in spelling and phraseology and a too evident carelessness in the use of ordinary English, however, to win the approval of the scientist or purist in language.

NEUROLOGISCHE WANDTAFELN ZUM GEBRAUCH IM KLINISCHEN, ANATOMISCHEN UND PHYSIOLOGISCHEN UNTERRICHT. Revised second edition of the Icones neurologicae. By A. VON STRÜMPELL and CHARLES JAKOB. Published by Friedrich Müller, Chief of the II medical clinic, and Hugo Spatz, Privatdozent of Psychiatry in Münich. Price, 108 marks, with stronger paper, 147 marks and with description of charts, 4 marks. Eleven charts in color. Münich: J. F. Lehmanns, 1926.

Every neurologic laboratory is familiar with the old Strümpell and Jakob charts. The second edition of this well known series has just appeared. It is a vast improvement over the first and consists of twelve charts in color, which are excellent; in fact, after looking them over it is difficult to see how they could be improved. Every neurologic laboratory should have a copy. They are invaluable to the teacher of neurology.

DAS NEUROSENPROBLEM VOM LEBENSWISSENSCHAFTLICHEN STANDPUNKT. By DR. EDGAR LEYSER. Berlin: S. Karger, 1927.

This brochure of sixty-six rather closely printed pages offers a painstaking, carefully considered, philosophic discussion of the neurosis problem, in which the conception developed by Palagyi is particularly stressed. Students of the subject will find in it much food for thought.